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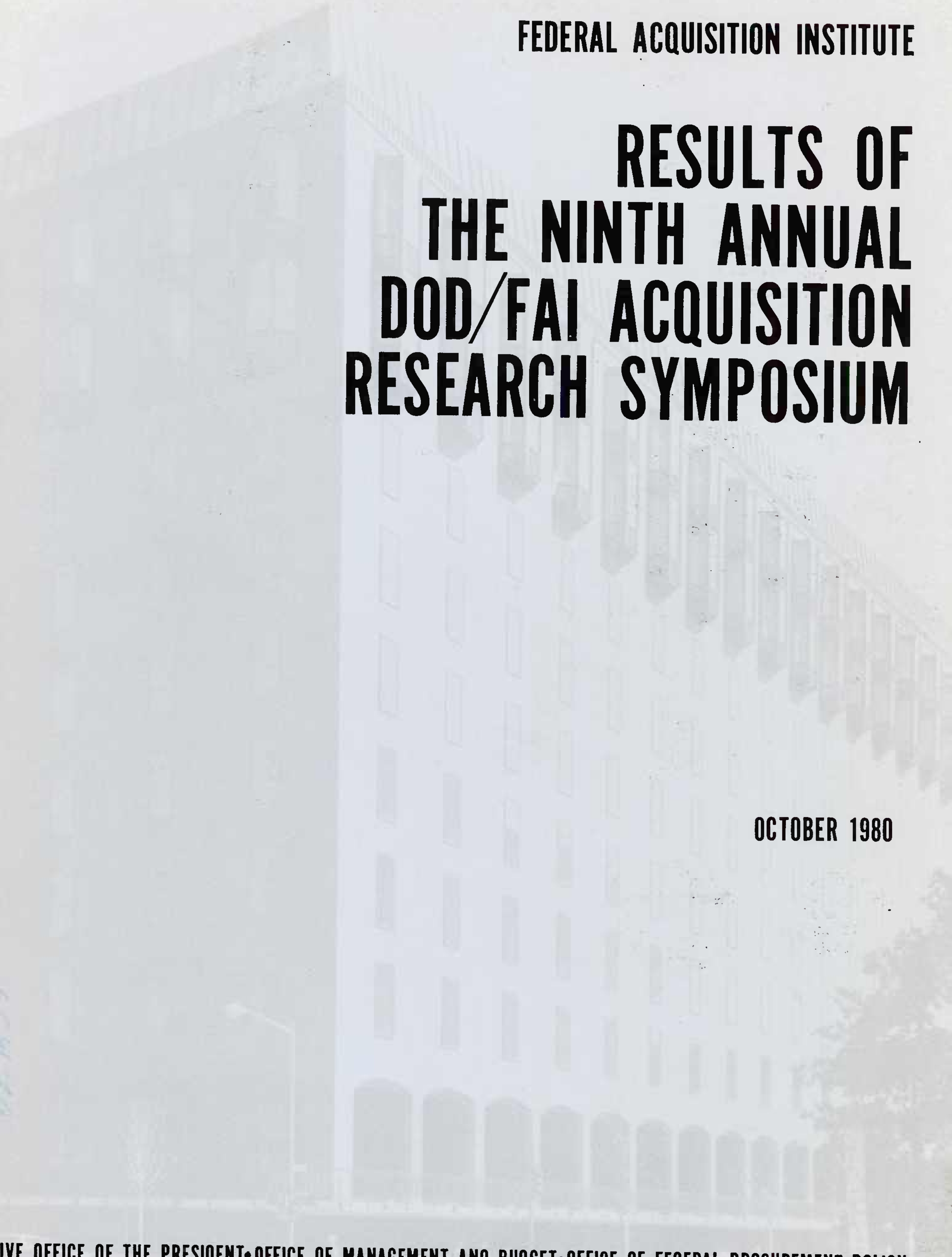

RESULTS OF THE NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM

OCTOBER 1980

IVE OFFICE OF THE PRESIDENT • OFFICE OF MANAGEMENT AND BUDGET • OFFICE OF FEDERAL PROCUREMENT POLICY

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

OFFICE OF FEDERAL
PROCUREMENT POLICY

F O R E W O R D

These Highlights and Summary of the Ninth Annual DOD/FAI Acquisition Research Symposium were prepared by Dr. Thomas C. Varley of the Office of Naval Research, Symposium Chairman, and Mr. Joseph C. Spagnola, Acting Director of Research of the Federal Acquisition Institute for use by Federal executives in determining future needs and actions in procurement and acquisition research.

In the Keynote Speech at the Symposium, Dr. John P. White, Deputy Director of the Office of Management and Budget asked that the FAI, with OFPP, assess which ideas or topics from the Symposium should be followed by action leading to implementation, further research or added sponsorship. This pamphlet is the beginning of that assessment.

This summarization is based on the referenced research papers and, therefore, does not necessarily represent the official viewpoint of the Federal Government. Copies of the 700-page Proceedings of the Symposium, containing all of the research papers referenced in this summary, were forwarded to all attendees. Reference copies are available in the Federal Acquisition Institute Library located in the Magazine Building, 1815 North Lynn Street, Rosslyn, Virginia. Reference copies have also been deposited with the Defense Technical Information Center (DTIC), the Defense Logistics Studies Information Center (DLSIE), and the National Technical Information Service (NTIS).

Correspondence relating to procurement and acquisition research should be addressed to Mr. William N. Hunter, Director, Federal Acquisition Institute, 726 Jackson Place, N.W., Washington, D. C. 20503. The FAI will monitor follow-up actions and render all assistance possible to assure maximum effective results from the coordinated actions of all concerned.

Karen Hastie Williams

Karen Hastie Williams
Administrator

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NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM

HIGHLIGHTS

The Summary section contains the essence of most of the research papers presented at the Symposium. Oral presentations were made in sessions chaired by Session Managers selected for their recognized expertise in the subject matter. Each Session Manager chose other technical experts to serve with him as Panel Members. These Highlights include some of the most important conclusions and/or recommendations from an analysis of the research papers and panel deliberations.

In his Keynote Speech at the Symposium, Dr. John P. White, Deputy Director of the Office of Management and Budget, asked that the Federal Acquisition Institute assess which ideas or topics from the Symposium should be followed by action leading to implementation, further research or added sponsorship. He proposed a review of these follow-up actions, periodically and at next year's Symposium. As a highly qualified research executive himself, even before he came to Government, Dr. White is keenly aware that, all too often, good research ideas die for lack of organized "follow-through" action. The establishment of this mechanism to maximize the effectiveness of the results of the Symposium is, by and of itself, the most important "highlight."

The Administrator of the Office of Federal Procurement Policy has a statutory responsibility for "promoting and conducting research in procurement." In her remarks at the Symposium, Mrs. Williams not only reiterated the importance of this function in her myriad responsibilities, but related it to the highest priority project in OFPP, the proposal for the Uniform Procurement System (UPS) required by Public Law 96-83 to be submitted to the Congress. She called on the procurement research community to take advantage of this opportunity to be innovative and to help devise a Uniform Procurement System that will represent a bold step forward. So, the time for action in procurement and acquisition research is now. The results from this Symposium become available at a propitious time.

The theme for the Symposium, "Acquisition of Affordable Systems in the 1980's," was timely, stimulating and provocative. The expressions of the attendees, including research paper authors and panel members, indicate that inflation, the ever-increasing complexity of all aspects of acquisition, and other factors have fostered growing recognition of the need for effective techniques to assure realistic consideration and control of the "affordability" considerations. A number of the research papers treat the subject. Effective action leading to implementation is needed for the research concepts which have merit. Some require further research and testing.

The need for a critical look at affordability considerations is best dramatized by statistics used in one of the research papers which cites a recent GAO report as its source. The report indicates that it would require approximately $72.5 billion annually for the next 10 years just to complete procurement of the Department of Defense systems currently in development or production. Obviously, this condition is created by many actions and inactions having their roots in Congress, the Executive Department, and the national and world economic and political situation, in addition to those under the management and control of the DoD. Contributors to the causes and cures of affordability problems are treated, at least indirectly, in many of the research papers.

OMB Circular A-109 and the departmental implementation documents and procedures concerning major system acquisition are critically analyzed in some of the research papers. One conclusion was that DoD is clearly progressing toward getting affordability, mission needs and mission budgeting issues under control and improving the front-end of the acquisition process. Problems persist in many parts of the process and the research indicates solutions to some of these and recommends further acquisition research in others. Some recommended improvements include: (1) top down mission analysis to identify and scope needs in the context of an overall mission area; (2) expression of needs in mission requirements terms; and (3) concurrent consideration of affordability in the Program Planning and Budget System (PPBS) and the Milestone 0 decision in the Defense Acquisition Review Council (DSARC).

This latter recommendation is fostered by the recently revised major system acquisition documents in DoD (DoDD 5000.1 and DoDI 5000.2) which also direct affordability decisions at other milestone decision points and closer alignment with the PPBS. Since mission area budgeting has been mandated by Congress in the Budget Control Act of 1974, mission area analysis must be linked closely to PPBS. Mission area breakdowns for a structure for an affordability analysis which can be a useful tool in building the annual Program Objective Memorandum (POM). Annual POM development provides a check on affordability considerations at each milestone. The only disconnect that can occur is a dramatic change in priorities.

The lack of financial management involvement directly with the acquisition research community was identified as a weak link in improving acquisition research. It was recommended that a financial management research sponsor be added to the Defense Acquisition Research Council (ARC). The Defense Acquisition Research Element (DARE) Working Group of the Military Departments and the DSMC support the ARC and the Acquisition Research Coordinating Council. The function of the DARE is covered in detail by one of the research papers. A similar recommendation would be appropriate for the Civil Agency Acquisition Research Council (CAARC).

The lengthening of the acquisition cycle is of major concern in many of the research papers. One paper indicates that the total time to develop and produce a new aircraft to initial operational capability has been increasing at the rate of three months per year for the past fifteen years, while the interval from design contract to first flight remains constant. It concludes that all that has been added is costly administrative time. This research concludes that significant savings can be realized by simplifying the process through which it is determined that a given effort is affordable. Another research effort had an original objective of ascertaining how the management review process incident to DSARC milestone decisions affects the length of major systems acquisitions. It was found that the management review process tends to parallel the technical development of the system and its length is a function of the chain of command within the reviewing organization and that the DSARC process does have a significant impact on the length of the cycle. The author suggested that further examination into areas such as funding problems, testing requirements and concurrency may prove useful in shortening the cycle. Still another investigation considered the possibility that OMB Circular A-109 might be causing the process to lengthen. The conclusion was that it was too soon to be able to determine.

Another research effort considered the lengthening of production and manufacturing lead times and suggested the need to examine surge capability in the United States, particularly at the subcontractor level. It was indicated that a "get well" program might need to be developed with, for example, mobilization base funding for improving capabilities in forging, casting, etc. A related area of concern was the cost of certain shipboard equipment and the excessive lead time when production stops shortly after initial acquisition and parts support is disrupted. Lead times of two to five years at very exorbitant costs are experienced. Further research is suggested. Disruptive costs were considered in another paper related to methodologies and models for estimating the cost of such disruptions.

Many problems of international collaboration need penetrating research especially in regard to the comparative analysis of industrial structures within the NATO partners and the comparative analysis of legal structures and institutions. Since it appears that International Collaboration will play a major role in future systems developments, alternative methods and structures must be considered. For example, the differences in National Objectives, as well as how these objectives are filled, is not understood by the U.S. project offices. A possible alternative would be a special office to carry out these functions for all Program Managers.

Some comprehensive research is included on cost estimation. One of the contributors to the kind of situation, when so many more programs are started than can be funded, is poor cost estimating. One

comprehensive research paper surveyed a number of prior studies which focused on cost, cost estimation and cost analysis. A major issue is the "semantics of cost." One basis of misunderstanding about cost estimates is the diversity of various methods and techniques. There is a need for some mechanism to minimize misapplication of techniques. Pricing people, cost analysts, economists and industrial engineers need some common ground to discuss cost. There is a definite need to develop a "text" on various analytic techniques and methodologies. Cost estimation is described as more art than science. Cost models, parametric cost estimations, and computerized life cycle cost models are included in several research papers but the need for additional research is evident.

Profit Policy headed the list of research papers on contract pricing. A paper on DoD's profit policy demonstrated the difficulties of trying to define meaningful measures of profit. The addition of return on facilities capital investment has not been a positive motivator to increase their facilities investment. The factor was recently increased. The productivity award factor is difficult to define and measure. The profit factor for independent research and development was intended to provide additional profit when acquiring items that were independently developed and has not been used as intended.

Research on Economic Price Adjustment provisions advances the theory that continued use of escalation provisions without careful consideration does not encourage contractors to apply management tools to minimize the effects of inflation. The researcher showed that it is possible to estimate inflationary price increases with some degree of certainty, and that the use of economic price adjustment clauses should be limited with more reliance being placed on forward pricing techniques.

Research on the subject of competition is extensive and varied. One research paper reports on a comprehensive study for DoD on the enhancement of competition. The research was on-going at the time the paper was prepared but some of the observations and recommendations are included. Another comprehensive paper which examines the concept and structures for competition concludes that there is no single technique that will insure competitive buys. The research indicates that the basic mechanism exists for injection of competition and the key seems to be reliance on the competitive market and the application of judgement in the area of acquisition planning. Other research warns of the dangers of the misuse of competition when it is not desireable. Still other research covers cost benefit studies related to competition, maintaining competition while protecting the industrial base and many other aspects.

Research on program and contract management is quite extensive. Papers included research on Joint Service Programs and computerized program planning and management techniques. Inter-organizational sharing of automated resources was also studied. As a special feature of the Symposium, live demonstrations of computerized systems were presented by personnel from the Army, Navy, Air Force, GSA, Energy, NASA, and the Small Business Administration. Research into the interface between the program manager, the policy maker and the acquisition researcher produced some interesting findings. The need for effectiveness in the relationship between these three key players was demonstrated.

Research on productivity raised questions involving the integrity of the feedback system used to delineate a requirement, the qualitative and quantitative impact of the improvement and the output measures, the ability to sustain an improvement once achieved and demonstrated in the short term, institutional disincentives, and creating a climate to encourage productivity improvement. Further research is recommended in these areas.

Research on procurement and acquisition methodology included the Acquisition and Distribution of Commercial Products (ADCoP) under the new Federal policy and "Contracting Out" under the provisions of our B Circular A-76, as well as an examination of methods being used by industry to see what can be learned which could or should be applied within Government. Other research included new ideas on the use of incentives, including award fee, leader/follower, second-sourcing and other techniques and methodologies.

Research conducted in the areas of acquisition logistic support, production planning and manufacturing technology, and product assurance produced some results which should be evaluated for implementation or further research.

A few research papers were presented on Assistance and Cooperative Agreements in view of the fact that the Federal Grant and Cooperative Agreement Act of 1977, Public Law 95-224, contains statutory provisions covering contracts, grants and cooperative agreements. The Office of Management and Budget has been charged, under that law, with publishing interim guidance, conducting a study and making recommendations to Congress. The interim guidance is presently being revised.

Research on the procurement and acquisition workforce is the most important, most needed and, at the same time, yielding some of the most effective results. The Federal Acquisition Institute (FAI), with limited resources, has a number of far-reaching research activities in process. One is the project to encourage research on the information requirements of the acquisition community. The FAI has no plans to physically develop and operate an information system. Instead they are in the

role of research to produce the specification for the system. The current results and future needs are included in the summary and in one of the research papers. Other major research accomplishments and identification of future research needs include a survey of 20,000 Federal civilian and military personnel using established occupational analysis methodology and the establishment of new families of positions. Other major research and results are in the areas of training and education, authority of the Contracting Officer, organizational placement of the procurement function and the selection and career management of procurement personnel. Since FAI has the Civil Agency Acquisition Research Council (CAARC) as an inter-agency work group, is a member of the DARE working group and responsible for the follow-up on the research results from the Symposium, their role in successful results is paramount.

During the closing plenary session of the Symposium, Mr. William N. Hunter, Director of the Federal Acquisition Institute, presented awards to the authors of research papers selected as the best by a group of qualified members of the National Contract Management Association (NCMA) using established criteria. As a professional society, NCMA is active in stimulating acquisition research and promoting the writing of research papers.

The selected papers and authors are:

1st Place - David L. Herington and Gerald W. Kalal, "Economic Price Adjustment Provisions in Government Contracting and Suggested Alternatives"

2nd Place (tie) - Dr. Edward M. Kaitz, "NATO RSI and National Industrial Structures"

- Dr. Joseph L. Hood, "Training in the 80's)

3rd Place - Jack A. Holt, "Production Decision Framework: A Dynamic Planning Model"

4th Place - E. B. Cochran, "A Generalized Approach to the Improvement Curve" (This author passed away since the Symposium.)

5th Place - Richard C. Brannon, "Forecasting Savings from Repetitive Competition with Multiple Awards"

NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM

SUMMARY

1. Introduction.

The Ninth Annual DOD/FAI Acquisition Research Symposium with the Department of Defense and the Federal Acquisition Institute as co-sponsors and the United States Navy as host, was held at the United States Naval Academy on June 9, 10, and 11, 1980. The theme for the Symposium was "Acquisition of Affordable Systems in the 1980s". The purposes were to present research papers concerning on-going and completed acquisition research related to specific areas of the acquisition cycle, and to provide a forum for open discussion of the issues involved among qualified individuals in government, industry and academia. This Summary is designed to integrate the results and directions of acquisition research from this symposium for future application.

2. Background.

Beginning in 1972, the Department of Defense sponsored an annual Symposium to share procurement research results among the academic, business and acquisition management communities. A series of events and activities had endorsed the need for employing research to improve the effectiveness and efficiency of the systems acquisition and support process. One of the recommendations from the DOD Pricing Conference in 1967 dealt with the need for a Department of Defense Procurement Research Laboratory. In 1969, the Army Procurement Research Office was established and in 1970, the House Government Operations Committee concluded that there was a need for a procurement research laboratory for DOD. In 1971, the Department of Defense established a Procurement Research Coordinating Committee. In 1972, the Commission on Government Procurement recommended the establishment of a Federal Procurement Institute with responsibility, among other things, for conducting and sponsoring research in procurement policy and procedure. The Air Force Business Research Management Center was established in 1973.

A number of significant events occurred in 1977. The Naval Center for Acquisition Research and the Federal Acquisition Institute were established. Also, in 1977, the Defense Department issued a directive to formalize the Acquisition Research Program of the DOD and to coordinate its program with the Federal Acquisition Institute. The same year the General Accounting Office issued a report which called for the establishment of a strong Government-wide program of procurement and acquisition research.

In 1978, the title of the annual research symposium was changed from the DOD Procurement Research Symposium to the Acquisition Research Symposium to reflect the broader scope and responsibility being accepted by the acquisition research community. In 1979, the title was changed to the DOD/FAI Acquisition Research Symposium. Acquisition research is moving rapidly to be responsive to the needs of the total acquisition process and the applicability of the results throughout the Federal Government.

3. The Role of the Federal Acquisition Institute in Acquisition Research.

The Office of Federal Procurement Policy Act Amendments (P.L. 96-83, October 10, 1979) includes, "(4) promoting and conducting research in procurement policies, regulations, procedures and forms, through the Federal Acquisition Institute, which shall be located within the Office and directed by the Administrator;". It further provides, "(6) recommending and promoting, through the Federal Acquisition Institute, programs of the Office of Personnel Management and executive agencies for recruitment, training, career development, and performance evaluation of procurement personnel;". The Act stipulates that one-third of the funds appropriated for the Office of Federal Procurement Policy (OFPP) shall be made available to the Federal Acquisition Institute for the functions under the Act. This increased emphasis on Acquisition Research was clearly evident in the extent of Civil Agencies' participation in the Ninth Annual DOD/FAI Acquisition Research Symposium.

4. Structure of the 1980 Symposium.

The "Call for Papers" issued jointly by the Department of Defense and the Federal Acquisition Institute in October 1979, invited the submission of Abstracts of candidate research papers in a broad spectrum of acquisition research topics. It was planned to select six research papers in each category for preparation, publication and presentation. Session titles are listed in Table 1. Following the opening plenary session on Monday morning, four or five sessions of three hours duration each were conducted concurrently on Monday afternoon, Tuesday morning and afternoon and Wednesday morning followed by a closing plenary session. During the concurrent sessions research paper presentations consisted of fifteen to twenty minute summarizations highlighting: what the problem was, why it was important, how the researcher focused on the methodology, where the research area occurs in the acquisition cycle, how the results of the research will be implemented and who will be the user. Each Session Manager selected three or four other subject-matter authorities as Panel Members, with a balance of representation from the DOD Civil Agencies, business and academia, to comment on the presentations in addition to questions and comments by the attendees.

5. Participation by Government, Industry and Academia.

The increased emphasis on acquisition research was evident in the type and degree of participation by the segments of Government, industry and academia. Tables 2 and 3 depict their participation by numbers of individuals from each who authored abstracts and research papers. Attendance at the symposium is shown by those who were authors, panel members or invited attendees. Table 4 examines the Civil Agency participation by individual department and agency.

TABLE 1

NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM

SESSION TITLES

- PROGRAM MANAGEMENT
- FRONT-END AFFORDABILITY, MISSION NEEDS, MISSION BUDGETING
- PRODUCTIVITY
- CONTRACTING METHODS
- PRICING
- COMPETITION
- FEDERAL BUYING AND ORGANIZATIONAL BUYING
- CONTRACTING ENVIRONMENT
- LOGISTICS/ILS
- PRODUCTION PLANNING AND MANUFACTURING TECHNOLOGY
- PRODUCT ASSURANCE
- COST ESTIMATING
- FINANCIAL MANAGEMENT AND AND BUDGETING
- INTERNATIONAL COLLABORATION
- PROCUREMENT AUTOMATION AND MIS
- ASSISTANCE AND COOPERATIVE AGREEMENTS
- PROCUREMENT PEOPLE, PROFESSIONALISM, AND ORGANIZATION

NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM
PARTICIPATION ANALYSIS

ABSTRACTS AND RESEARCH PAPERS

TABLE 2

TYPE OF PARTICIPATION	DEPARTMENT OF DEFENSE (C=CIVILIAN; M=MILITARY) OSD C	OSD M	DLA C	DLA M	DSMC C	DSMC M	ARMY C	ARMY M	NAVY C	NAVY M	AF C	AF M	DOD TOTAL C	DOD TOTAL M	CIVIL AGENCIES (COMBINED)	ACADEMIA (NON-MILITARY COLLEGES & UNIV.)	INDUSTRY (M=MFG; S=STUDY) M	INDUSTRY S	TOTALS
AUTHORS																			
184 Authors of Abstracts (includes multiple Authors)	3	1	11	1	7	0	13	0	5	7	32	20	71	29	15	31	6	32	184
Total Authors	4		12		7		13		12		52		100		15	31	38		184
Percentage (%)	22		7		4		7		7		28		54		8	17	21		
ABSTRACTS																			
152 Abstracts	4	1	11	1	5	0	12	0	3	6	16	22	51	30	14	18	8	26	152
Total Abstracts	5		12		5		12		9		38		81		14	18	39		152
Percentage (%)	3		8		3		8		6		35		53		9	12	26		
RESEARCH PAPERS																			
106 Research Papers	3	1	6	0	4	0	10	0	1	5	12	14	36	20	14	14	5	17	106
Total Research Papers	4		6		4		10		6		26		56		14	14	22		106
Percentage (%)	4		6		4		9		6		24		53		13	13	21		

TABLE 3

NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM
PARTICIPATION ANALYSIS

434 Registrants

TYPE OF PARTICIPATION	DEPARTMENT OF DEFENSE (C=CIVILIAN; M=MILITARY) OSD C	OSD M	DLA C	DLA M	DSMC C	DSMC M	ARMY C	ARMY M	NAVY C	NAVY M	AF C	AF M	DOD TOTAL C	DOD TOTAL M	CIVIL AGENCIES (COMBINED)	ACADEMIA (NON-MILITARY COLLEGES & UNIV.)	INDUSTRY (M=MFG; S=STUDY) M	INDUSTRY S	TOTALS
AUTHOR/ PRESENTOR	3	1	8	1	2	0	10	0	1	6	12	13	34	21	13	15	6	27	116
TOTAL	4		9		2		10		7		23		55				33		
Percentage (%)	4		8		2		9		6		20		47		11	13	29		
PANEL MEMBERS	4	3	2	0	1	1	2	2	3	4	4	5	16	15	24	2	8	10	75
TOTAL	7		2		2		4		7		9		31				18		
Percentage (%)	9		3		3		5		9		12		41		32	3	24		
ATTENDEE	9	0	6	1	6	1	28	4	21	17	14	15	84	38	71	9	13	28	243
TOTAL	9		7		7		32		38		29		122				41		
Percentage (%)	4		3		3		13		15		12		50		29	4	17		
SUBTOTAL	16	4	16	2	9	2	40	6	25	27	28	33	134	74	108	26	27	65	434
TOTAL	20		18		11		46		52		61		208		108	26	92		434
Percentage (%)	5		4		3		10		12		14		48		25	6	21		

TABLE 4

NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM
PARTICIPATION ANALYSIS
CIVIL AGENCIES

AGENCY	AUTHOR/ PRESENTOR	PANEL MEMBER	ATTENDEE	TOTAL
USDA			5	5
CIA			2	2
DOC		2	9	11
DOEd	1		2	3
DOE	2	4	5	11
GAO		1	2	3
GSA	1	3	5	9
HHS	1	2	6	9
HUD				0
DOI	2		3	5
DOJ			2	2
DOL			2	2
NASA		4	7	11
NSF			3	3
OMB	3	5	4	12
(OMB)		(2)	(1)	(3)
(OFPP)		(2)	(1)	(3)
(FAI)	(3)	(1)	(2)	(6)
OPM	1	3	1	5
DOT	2		12	14
DOTr			1	1
TOTALS	13	24	71	108

6. The Opening Plenary Session.

Dr. Thomas C. Varley, Symposium Chairman, opened the session and introduced RADM William P. Lawrence, USN, Superintendent of the United States Naval Academy who welcomed the attendees. Mr. Dale W. Church, Deputy Under Secretary of Defense (Acquisition Policy) spoke on behalf of that department as one of the co-sponsors. He emphasized that there was less money available in a practical sense due to inflation and the increased cost of spares and support. He stated a need to stabilize the market place and endorsed the advantages of multi-year contracting. He also called for better cost estimating. Following his remarks he introduced the Honorable Karen Hastie Williams, the Administrator of the Office of Federal Procurement Policy who spoke on behalf of the Federal Acquisition Institute, the other co-sponsor. Mrs. Williams briefed the attendees on the massive effort being put forth on the Uniform Procurement System (UPS) being developed for submission to the Congress as required by P.L. 96-83. She expressed her gratitude for all of the cooperation she was receiving in this and other tasks. She emphasized that acquisition research was an integral part of the UPS.

7. The Keynote Speaker.

Mrs. Williams introduced Dr. John P. White, Deputy Director of the Office of Management and Budget, the Keynote Speaker. Dr. White called for improved management incentives and stressed "affordability", the key word in the symposium theme, as being a very fundamental issue that must be paramount throughout the life cycle of systems. He cited the need for improved productivity and forecast that the pressures on more efficient procurement would persist. He charged the attendees to:

- Change management emphasis away from legalities of contracts to the broader aspects of business management.
- Aim at big problems - "what ought to be".
- Avoid sloganeering and stick to work fundamentals.
- Base decisions on facts - watch the data.
- Pay attention to institutions and determine the impact of new policies.
- Listen to what the practioners say.

Dr. White also spoke on the relative health of the Office of Federal Procurement Policy and emphasized that it is here to stay. He said it was functioning largely as the Commission on Government Procurement envisioned. He listed the priorities as: the UPS, improvement of the workforce, the Federal Acquisition Regulations, Acquisition and Distribution of Commercial Products (ADCoP), development of standard contract language, central management systems like A-76 and A-109 and concentrating on oversight. In closing Dr. White said he had selected the critical topics for his keynote address to highlight the major contributions the attendees could make. He said the pressures and restraints were growing and that the need was to be smarter, more effective and practical.

8. Rand Presentation.

To further prepare the attendees for the separate concurrent sessions which were to follow, Mr. Robert Perry of the Rand Corporation gave a presentation on "Acquisition Lessons Learned in the 70's". The principal points made were:

- Raw data shows that DOD programs of the 70's were better managed than those of the 60's and were better managed than those of other Federal agencies.
- Data does not support the claim that programs are taking more time and investment rates increasing. Rate of investment in constant dollars is the same.
- Hardware demonstration is effective. Arguments that prototyping is expensive and takes too much time are not supportable.
- Packard prototyping has significant advantages.
- Type of contract is of no real value, share ratio differences are not meaningful.
- Reliability Improvement Warranties are not working.
- Cooperative collaborative programs will be big in the 80's.

9. Research Results and Direction.

A desirable degree of overlap was inherent in the eighteen topic areas in which abstracts of research papers were invited for the symposium. With certain exceptions (e.g., International Collaboration, Federal Buying and Organizational Buying, and Procurement People, Professionalism, and Organization) these results will not be portrayed in the structure of the individual topics but rather as they relate to the chronological structure of the acquisition process. However, as you view the Acquisition Cycle from the cradle to the grave several important facts are evident. The interdisciplinary nature of the total process must be considered. Acquisition is an integrated, interactive system which resists the arbitrary grouping of activities. A recently published Department of Defense Guide, "A Guide to Resources and Sources of Information for Acquisition Research", January 1980, includes research categories which are to some extent chronological and generally follow the successive phases of the acquisition process. The research categories are:

a. Requirements Planning.

b. Business Environment.

c. Cost and Economic Analysis.

d. Business/Procurement Strategy

e. Program/Contract Management.

f. Acquisition Logistics Support.

g. Human Resources Management.

The research categories were further divided into descriptions which are depicted on Table 5.

10. References.

Parenthetic references throughout this Summary are to research papers published in the Proceedings of the Ninth Annual DOD/FAI Acquisition Research Symposium. The related footnote number is keyed to the name(s) of the author(s) only, at the bottom of that page and to a citation of the full title of the research paper, the name(s) of the author(s) and page reference which will be found in the Reference Section at the end of this Summary. Not all research papers included in the Proceedings will be cited or referenced. As in past symposia in this series, about one-half of the papers are "descriptive" and half are "diagnostic". This Summary will highlight those in the latter classification, especially where a need for further research is indicated.

Table 5

ACQUISITION RESEARCH TOPICS

Requirements Planning

1. Technology Base (Research & Development)
2. Mission Needs
3. Budget/Appropriations
4. NATO (International Collaboration)

Business Environment

5. Legal/Regulatory/ Policy Influence
6. Socioeconomic Considerations
7. Cost Inflation

Cost & Economic Analysis

8. Cost Estimating
9. Life-Cycle Cost
10. Economic Analysis
11. Cost Analysis
12. Analytical Techniques

Business/Procurement Strategy

13. Industrial Base
14. Contract Planning
15. Scheduling Factors
16. Procurement Methodology
17. Contract Formation
18. Evaluation/Source Selection
19. Contract Pricing

Program/Contract Management

20. Program Management
21. Contract Management
22. Property Administration
23. Contract Changes/Modifications
24. Cost Monitoring/Control
25. Quality Assurance

Acquisition Logistics Support

26. Logistics Support
27. Reliability/Availability/ Maintainability
28. Configuration Management
29. Warranties
30. Provisioning
31. Foreign Military Sales

Human Resources Management

32. Management Techniques
33. Career Development
34. Acquisition Work Force

A. REQUIREMENTS PLANNING

11. Affordability.

The use of the word "affordability" as the key word in the Symposium theme produced papers in several disciplines related to the affordability problem. Affordability is defined as the ability to program and budget adequate resources to execute a program in an efficient and effective manner. It is the ability to develop and procure a system for inventory without resorting to schedule stretch-outs and low, uneconomical production rates. One paper stated that affordability was acknowledged to be the single greatest problem facing the U.S. Defense community (1). The new DOD affordability policy has been placed in the new complete revisions to Department of Defense Directive (DODD) 5000.1, "Major Systems Acquisitions" and Department of Defense Instruction (DODI) 5000.2, "Major Systems Acquisition Procedures", dated 19 March 1980. Both publications make it clear that affordability is principally determined through the Program Planning and Budget System (PPBS) and provide that affordability begins at Phase "0", Concept Exploration and will be a key decision factor at each successive milestone in the Defense Acquisition Review Council (DSARC) system. The concept calls for reconciliation of the DSARC and PPBS processes so that the two defense management mechanisms work together, not in isolation or conflict. A major program within DOD reaches Milestone "0" and enters the acquisition process upon approval of the Mission Element Need Statement (MENS). This is the first of four key decision points suggested by Office of Management and Budget (OMB) Circular A-109, 5 April 1976, and is the point at which the agency must reconcile its mission needs with its capabilities, priorities and resources. The affordability policy in DOD is now an important link between A-109, the DSARC and the PPBS systems. Concurrent consideration of affordability and force prioritization is obtained in the PPBS and Milestone "0" decisions.

Another research paper (2) argues that affordability considerations can, if properly implemented, improve the system acquisition process. This paper advances the thesis that proper emphasis on affordability could stabilize or reverse negative trends that have developed in the system acquisition process. It holds that, on the average, the total time to develop a new aircraft to IOC has been increasing at a rate of three months per year for the past 15 years, while the interval from design contract award to first flight has remained approximately constant. All that has been added is costly administrative time. Affordability analyses consisting of an evaluation of needs in relation to anticipated resources availability can help determine the most important things on which to concentrate. New low level efforts seem affordable when first appearing in the R&D budget but as programs evolve they gain momentum, constituencies, and collectively add up to more than can be afforded when costed out over the longer term.

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1. Baldwin, Truxton R.,
2. Kollmorgen, Rear Admiral Leland S., USN.

The paper describes how, at the National level, the problem is being dealt with as a result of the Budget Control Act of 1974 and the issuance of OMB Circular A-109. The point is developed that since mission area budgeting has been mandated by Congress, mission area analyses must be linked closely to the planning, programming, budgeting system (PPBS). It has not been. Mission area breakdowns form a structure for an affordability analysis which can be a useful tool in building the annual Program Objective Memorandum (POM). Annual POM development provides a check on affordability considerations at each milestone. The only disconnect that can occur is a dramatic change in priorities occasioned by changes in the threat, funding constraints, or perspectives of the principal participants. In the author's view, the most practical means of simplifying these divergences of opinion is by adopting the concept of affordability as outlined in his paper and strive to perfect the technique. Significant savings in the total cost of acquiring weapon systems can be realized by shortening the lead time necessary to progress from program initiations to fleet/unit operational introduction. Significant savings are judged possible by simplifying the process through which it is determined that a given effort is affordable. The need for additional research on the acquisition cycle is evident in an analysis of this research paper.

The objective of the research performed in preparing another paper (3) was to develop a management approach for addressing the affordability problem in the procurement funding area. It was determined that DSARC's role should be supportive of the PPBS in affordability determinations because affordability deals principally with the question of how to allocate finite budget resources to competing programs. An affordability matrix was developed for use by the services in developing its own 15-year baseline procurement program.

Still another research paper (4) describes a computer model for computing optimal distribution of acquisition funds among several systems. It is offered that one method for making defense systems more affordable is to purchase the required quantities over a short time period at a higher production rate. This method requires additional funds early in procurement to produce savings later in the procurement. When affordability is addressed on a system-by-system basis, obtaining the additional up-front funds is often difficult. The paper presents the first iteration in the development of a computer model to determine optimum allocation of funds among multi-system procurements. The use of readily available data showed a large potential for lowering acquisition costs through use of the model, resulting in increasing overall affordability.

12. Mission Needs.

A research paper on mission analysis (5) suggests that in DoD the "birth phase" of a program up to Milestone "0" has lengthened significantly

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3. Moeller, William G..
4. Schumacher, Lee A..
5. Sutton, Jerome P..

during the past two decades, from less than two years prior to 1960 to nearly five years in the current decade. Observing that it is only four years since OMB Circular A-109 became effective, this paper states it is too soon to determine whether the requirement for the Milestone "0" decision point has or has not lengthened the process. The paper examines the prescribed activity which precedes that event and concludes that there is a good possibility that the lengthy decision process (at least in the USAF where the research was performed) may adversely affect the period. To counter this, it is offered that the mission analysis function, when properly implemented by the product division, has a reasonable possibility of shortening program birth time. Consideration of this paper in a study on shortening the acquisition cycle should prove fruitful.

A research paper which discusses a top-down approach to the preparation of a Mission Element Need Statement (MENS) proposes a functional analysis of the mission statement as a process of defining and quantifying the need in the MENS (6). For illustrative purposes, the Navy Sea-Based Strategic Strike Mission is analyzed and a specific need for an improved mission capability is developed to demonstrate how the top-down methodology is applied. In the paper the MENS has been developed using the process of functional analysis of the mission statement. A statement of need has been prepared in functional terms, not system requirements. It fully supports the requirements for mission budgeting by detailing how a mission need will be met with the funding identified in the MENS. Top-down analysis identifies and scopes needs in the context of an overall mission area.

13. NATO and International Collaboration.

The first of six papers on International Collaboration (7) presents the "American View" toward the problem of international collaboration on Foreign Military Sales (FMS) as embedded in the official U.S. Government policy, in rules and regulations. In particular, the management systems related to FMS, the function of the Defense Systems Acquisition Review Council (DSARC), and of the Planning, Programming and Budget System (PPBS) have been highlighted. The U.S. Government organization for FMS and the OSD organization for FMS have been outlined including the responsibilities for the key members of the organizations. The paper can be considered as a highly condensed primer for the understanding of the program manager's responsibility and problems to be expected in any program relating to foreign military sales.

The second paper (8) expands the American policy view (as outlined in the first paper) toward a mutual American-European view by concentrating on the quantitative background of the arms trade among the NATO partners. Special attention is given to the trade between the United States, Great Britain, France, and Germany. The paper stresses the need for many political

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6. Garverick, CDR C. Michael, USN; Welsh, William L..
7. Cullin, William H..
8. Kanter, Herschel.

compromises by all parties involved. It appears, for example, that all partners are well aware of the inherent potential of a unified NATO market, but at the same time, Europe seems to put a major emphasis on the economic aspects of weapons export to countries outside of NATO. The paper states the problems of cooperation in factual terms and concludes that progress toward deepened cooperation will depend to a large degree upon the possibilities given to the European partners for early participation in the development of new weapon systems. This is because in the early stages many compromises can be made and issues connected with the sales of weapons outside of the Western Alliance be resolved much easier than "after the fact".

The next paper (9) takes off essentially where the previous one closes and concentrates on the European view towards the arms business. The paper examines in sufficient detail the apparent dependence of the European defense industry on arms export in four principal sectors ---aerospace, shipbuilding, ground armaments and electronics--for France, the UK, Germany, Italy, Belgium and the Netherlands. A comparative statistic of the European defense industry with the United States and Canada is given. The paper alerts to the European "foreign policy reasons" in response to the Third World demands and in the interest to maintain influence in regions considered vital for raw materials and energy. It appears as if Europeans would be inclined to consider the balance of military trade accounts as a very specific issue, disassociated from their overall balance of trade. This problem seems to the Europeans immediately related to their fear of "exporting" jobs and industry. Also in terms of overall workforce, the European defense industries are much smaller participants than the U.S. industry. They consider stability of even this small part of the labor market as essential within their social structure. The paper closes with the information that presently studies are in progress to collect a more detailed data base on the interaction between the European defense industry and the other European industrial structures.

The next paper on International Collaboration (10) reconstitutes the intellectual bound between the first three papers in a non-statistical fashion. However, the author in his oral presentation was able to support his views with ample data of the American and European industrial base--material taken from one of his studies currently in progress. His premise is "a key non-military rationale for promoting NATO RSI policy is the belief that a harmonization of the United States and European defense industrial base can serve to reduce the cost of developing, designing, and producing weapon systems". And he continues, "This thesis assumes that the economic behavior and industrial dynamics of the market for military goods is a mirror image of that for civilian goods." Later in the paper he explains that his latest research suggests that this mirror image does not exist across the board. It became quite apparent that the definition of rationalization might have quite different connotations for the American and the European viewer. The

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9. Gessert, Robert A..
10. Kaitz, Edward M..

European defense industry might very well be perfectly rationalized in cooperation between the European Industry and the European Government--rationalized for European political and social conditions. Europe might be satisfied with a small--although inherently inefficient and labor intensive defense industry as long as this industry is able to satisfy Europe foreign and internal political goals. It appears that the European defense industry is a rather controlled, or at least semi-controlled entity within an otherwise free economy. Hence, the marriage of the American view and the European view might suggest a contradiction--leading to potential problems. This author agrees with the previous author (1) on the need to enhance the military strength of our NATO alliance nor (2) has any doubt about the need to increase the purchasing power of our defense dollar. However, he does not take it as a foregone conclusion that these two objectives can be joined by attempting to harmonize two disparate economic structures which have both evolved (in Europe and the USA) in response to perceived national interests which, in and of themselves, are disparate.

The next paper (11) explores the international methods of intellectual property (IP) transfer, new strategies to foster this transfer, the roles of the industrial and DOD project managers, and emerging initiatives and recommended directions. He states in particular that the laws of our European allies in NATO covering rights in inventions, data rights and software are substantially different from those in the United States. He suggested that one way to solve all those problems might be the teaming of American and European companies with advantages to both. The driving force for U.S. industry will be to penetrate new markets in NATO. This arrangement would likely result in a competitive advantage for the contractor for U.S. procurements where NATO standardization and interoperability are an issue. It would also allow the U.S. firm to operate overseas on its own terms, rather than the terms dictated by the Memorandum of Understanding (MOU) created by the U.S. Government. As our European allies develop their own defense industries, the "teaming" mode can be expected to be the preferred manner for penetrating the European defense market.

The final paper on International Collaboration (12) identifies the factors which may affect the negotiation process when dealing with foreign firms and foreign government officials. Some cultural differences which might influence negotiations are reviewed. The research included personal interviews with US Negotiators from both the public and private sectors who have had extensive experience in negotiating with the German, Dutch, French and British. The author devotes separate sections on negotiations with firms from each country.

Many problems of international collaboration need penetrating research especially in regard to the comparative analysis of industrial structures within the NATO partners and the comparative analysis of legal structures

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11. Fargher, John S. W., Jr..
12. Allen, LCDR Daniel W., Jr., SC, USN.

and institutions. Since, it appears that International Collaboration will play a major role in future system developments, alternative methods and structures must be considered. For example, the differences in National Objectives, as well as, how these objectives are filled, is not understood by the U.S. Project Offices. A possible alternative would be a Special Office to carry out these functions for all Program Managers. Only mutual understanding can lead to mutual cooperation.

B. BUSINESS ENVIRONMENT

14. Legal/Regulatory/Policy Influence.

The landmark Supreme Court decisions, Bakke and Weber were researched to assess their impact on the present status of Affirmative Action Programs and the implications they present for the 1980's (13). Key questions included the viability of voluntary affirmative action plans, the role of the Equal Employment Opportunity Commission (EEOC) and the Office of Federal Contract Compliance Programs (OFCCP) in the process and the likelihood of the extension of the concepts to other minority groups. One half of the nation's industries are covered by Executive Order 11246, including some 175,000 companies and 41 million employees. The non-compliance sanctions of cancellation, termination, or suspension of Government contracts, and even disbarment, can be far reaching and seriously impact the acquisition community. The actions against Uniroyal Tire, St. Regis Paper and, most recently, Firestone Tire have demonstrated that. The impact and directions of these decisions must be clearly understood by Federal, private sector employers in order to prevent delays, pre-award complications, avoidable litigation, and misunderstandings which will clearly affect their ability to provide the goods and services contracted. The Affirmative Action Program has been one of the most controversial of the socio-economic programs imposed on the contracting process.

Another research paper (14) concentrates mainly on just one aspect of the new Amendments to the Small Business Act of 1978, P.L. 95-507. Implementation of the new provisions of that law has seriously impacted the acquisition community since its enactment in October 1978. Section 211 of the law provides that the low bidder or offeror on all Federal contracts of more than $1,000,000 for construction contracts, and $500,000 for all other contracts, must submit a subcontracting plan prior to award. The plan is to include percentage goals for the utilization of small business concerns and small business concerns owned and controlled by socially and economically disadvantaged individuals. The authors see this provision very favorably and even recommend lowering the threshold dollar amounts. The major portion of the paper deals with what they consider to be a major problem area in the small and small disadvantaged contracting sphere - that of a need for more technical and management assistance to small business by the private sector. They believe that P.L. 95-507 will promote the long-term viability of small and disadvantaged business concerns through the more active participation of private enterprise. A case of a major computer company establishing "Business and Technology Centers" designed to give small business, at a fraction of normal cost, many of the same resources available to larger companies is cited. The computer company recognized that the true innovaters in any business are small technically oriented entrepreneurs who have more creativity than money. The authors express the hope that their paper dispels some of the myths that have been

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13. Colachio, Jeanne M..
14. Patterson, Justin P.; Woods, Alton.

developed as a result of the misunderstanding of what P.L. 95-507 was enacted to do. More than just a means to funnel Government dollars to small and small disadvantaged business, the Act serves a more acute problem of small businesses, that of providing the technical and management know-how that will equip them to become viable enterprises capable of competing in the open market for not only a fair share of Government contracts, but also a share of business generated in the private sector.

C. COST AND ECONOMIC ANALYSIS

15. Cost Estimating.

A comprehensive research paper (15) includes a survey of several research studies and reports which focus on cost, cost estimation, and cost analysis as they apply to Government and industry in their interface as buyers and sellers. The paper analyzes the term "cost" in the context of both historical costs and future costs based on the two primary uses of cost by accountants and economists. A table of cost modifiers demonstrates that the most significant aspect of cost is the problem of cost definition and that the combinations of cost modifiers are almost endless. A taxonomy of cost terms is constructed using basic concepts from logic and mathematics. From the research conducted a generalized definition of cost was formulated which specifically ties meaning to the frame of reference and provides a foundation for an examination of the process of cost estimation. Cost estimation techniques are defined and described--specifically in relationship to the phases of weapon system acquisition and the contracting process. This research paper goes on to relate and differentiate between the functions of cost analysis and price analysis. Some past studies to improve pricing and costing techniques are referenced. This research paper concludes that "cost" is a multi-faceted term which can have different meanings based on specific context. In dealing with cost as a variable, the initial concern is a definitial one. All parties to that situation must agree on a specific meaning for "cost" based on a stipulated frame of reference. "Cost estimation" is more art than science. However, several techniques such as the expert opinion, analogy, statistical and industrial engineering approaches have their advantages. In the context of the weapon systems acquisition process, the statistical approach is useful in the conceptual and validation phases, whereas the industrial engineering approach is more suited to the full-scale development and production phases. "Cost analysis" is an evaluation of the cost estimates developed during the different phases and the approach used for developing the estimate must be considered. There is a need for research in the cost analysis area to determine the efficiency and effectiveness of the process. The relationships between cost, cost estimation, and cost estimation is an interdependent one. In the final analysis, cost analysis is a process of reconciling cost differences and developing an estimate of expected cost which has been derived using rigorous technical methodologies, tempered by judgement, and clearly understood by the parties involved. It further concludes that there is a need for research in the cost analysis area to determine the efficiency and effectiveness of the process including techniques and procedures.

Another paper (16) examines an engineers view of parametric cost estimation and the potential of parametric modeling of costs as he perceives it. Several technical problem areas in cost estimation analysis which require study are setforth. One area of technical analysis need is the

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15. Martin, Colonel Martin D.; Glover, Captain William L.,
16. Daschbach, James M.

measure of effect on manufacturing complexities for the company with increasing numbers of numerically controlled machine tools and CAD/CAM equipment. A second is the inclusion of the multi-product line effects on the cost and schedule estimates. Still another is the consideration of all parameters as qualitatively equal which may induce "error" into calculations. Finally, the author observes that cost parametric modeling does not have a means yet of measuring the influence of management expertise or training on the cost estimate. The paper concludes that parametric models appear to be one answer to better cost and schedule analyses but a lot of work still needs to be done in firming up the present known concepts and setting useable standards. In addition, there are several areas of further research work that will make parametric models a key decision-makers tool.

Another research paper (17) hypothecates that recent theoretical and empirical work in the areas of learning curves, production rate and cost estimation of airframes has seemed to yield contradictory conclusions. Empirical studies of airframe programs in the last five years have documented cases where increases in production rate have been associated with increases, decreases, and no change in the unit cost of production. The paper reports on the first stage of a research effort designed to synthesize the existing theoretical and empirical work that relates production rate and learning curves. The model developed in this research paper is a modification of a previous model, developed by this researcher, to include previous production experience and yearly production targets. This permits a production program to be modeled as a series of discrete tasks connected by experience. The impact of an exogenous increase or decrease in deliveries can be modeled, as well as the impact of stretching a lot out over a longer period of time. The paper also includes plans for estimating the cost function and illustrates its use in program management. The model permits the analyst to specify certain policy constraints and trace their implications on program costs. The model is seen to contain an explanation of the fact that sometimes production rate has been positively and sometimes negatively correlated with program costs. However, in the opinion of the researcher, more work needs to be accomplished to verify this hypothesis. In particular a careful job of estimating the cost function for several airframe programs needs to be done. This requires attention to the kinds of policy constraints in force at various times during the program. Much of the required data is still available and is referenced in the research paper. Interviews with contractors may also be required. The data sets need to be consolidated and transformed to provide consistent observations. The parameters of the model can be estimated for each airframe program. Finally, the estimated model can be programmed and used to provide timely, documented answers to questions about the cost impact of alternative policies.

Another research paper (18) presents a generalized approach to the improvement curve. It documents the premises that the traditional "learning

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17. Womer, Norman K..
18. Cochran, E. B..

curve" concept is only a "baseline" on which several complex irregularities interact. The main irregularities are: startup, rate changes, task changes, interruption and phaseout. Under certain conditions, any one of them can generate an increase of up to fifty percent in unit cost above the stable baseline. The author proposes a list of sixteen causal factors indicating the major irregularities each one affects as well as their interrelationships. His approach is to develop a general purpose computer program which estimates the labor hours for each major event or irregularity, using the sixteen causal factors. The program is being designed as an easy-to-use interactive procedure for contractors, procurement analysts and others directly associated with planning, estimating and evaluation of major acquisition programs. (Note: the author is now deceased).

A computerized life cycle cost model (TREAD) which has been developed for estimating the life cycle cost of advanced technology armored combat vehicle concepts as well as current inventory tanks, is described in another paper (19). The research was hampered by a lack of data for many subsystem cost categories for reasons that are explained in the paper. For a substantial fraction of the cost categories, where historical data were sparse or non-existent, or advanced technology components were involved, Cost Estimating Relationships (CERs) were synthesized based on appropriate analogs and engineering judgement, aided by advice from Government and contractor experts. The authors warn that the predictive capability of any cost model should be viewed cautiously because there are large variables that affect the actual cost of a system that are unrelated to vehicle or program characteristics. Some of these possible variables are specified in the paper. The TREAD model cannot claim to predict absolute costs with great accuracy, but it can produce good relative cost estimates between competing systems. The output format is flexible and can provide cost estimates for a total force, battalion, or a single tank either for life or per year. Cost estimates have been compared with estimates from other sources for validation. The model is being continually updated and is in use on the Armored Combat Vehicle Technology (ACVT) program.

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19. Fredericksen, Donald N.; Kornhauser, Bernard.

D. BUSINESS/PROCUREMENT STRATEGY

16. Federal Buying and Organizational Buying.

A paper by an industry expert (20) reviews lessons to be learned from the commercial world by Government acquisition managers. The author points out that these techniques have withstood the test of time and have proven their value in the demanding environment of the commercial marketplace. Points developed in the paper are: (1) find a good supplier and stick with him; (2) help the supplier make a good profit; (3) give him a free hand to manage his project; (4) give him a general requirement and let him make the detailed specification; (5) concentrate on cost reductions, not profit rates; (6) abandon the Invitation for Bid (IFB) syndrome of advertised procurement; (7) stop worrying about control of IR&D and B&P; (8) eliminate or reduce the termination for convenience clause; (9) use more innovative procurement techniques; (10) give contractors greater ownership in technical developments; (11) eliminate "best and final" offers; and, (12) reduce the usage of multiple incentive contracts. The author recognizes that when the Federal Government enters the procurement arena, Congress, the President and DOD and other Federal agencies have placed constraints on acquisition managers. He has written a provocative paper as if these constraints did not exist to highlight what needs changing from a purely commercial viewpoint. (NOTE: The Proposal for a Uniform Procurement System (UPS) being submitted to the Congress by the Administrator of the Office of Federal Procurement Policy (OFPP) in compliance with Public Law 96-83 will, no doubt, eliminate some of the constraints which inhibit following good commercial practices.)

A research paper by a university professor (21) reviews industrial purchasing techniques which would improve Government purchasing efficiency. The author prefaces his paper with the similarities and differences and attempts to show that the differences are more matters of degree than of kind, more trapping than substance. The differences which account for most obvious inefficiencies are: (1) budgeting; (2) life cycle costing; (3) price security; (4) freedom in source selection; (5) exerting leverage on suppliers; (6) lead time control. These areas are all discussed in the context of organizational relationships. The author cites Senate Bill 5, sponsored by Senator Lawton Chiles (D-Fla), although not impressive in terms of its volume, as reflecting policies and practices which have been demonstrated as being effective in the private sector. He sees the present era when the high cost of Government is under scrutiny as the time for needed change. (NOTE: The Uniform Procurement System (UPS) referenced in the previous paragraph will address the areas of S.5 to which this author refers in a more comprehensive manner).

Another research paper (22) covers the role of Marketing Communications in both the organizational (i.e. industrial) and the federal procurement process. The paper, authored by a professor of marketing, is conceptual in

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20. Corderman, Douglas G..
21. Hill, Richard M..
22. Galper, Morton.

nature based upon a review of prior research and literature, as well as the author's experience as a consultant to industrial firms. He observes that: (1) there are many parallels between organizational and federal buying with respect to the availability and use of marketing communications; (2) a body of knowledge has developed and is expanding on the subject which could prove useful to researchers and policy makers in federal procurement; (3) there is a strong movement in federal procurement policy (e.g. OMB Circular A-109) to increase the information flow between government buyers and suppliers, particularly at the front end of major systems procurement programs; and (4) there are some important differences regarding the access to marketing communications, especially in the later stages of the government buying process, when federal policy creates a constrained communications environment that could result in less satisfactory purchase performance. Examples of the latter are: (1) rejection of attractive bids or proposals on procedural/technical grounds, or (2) less competition as a result of fewer bidders, created by (a) complex procedures and paperwork, (b) exposure of bids to competitive/public scounting, (c) inability of small companies to manage the entire order, (d) inability to get modification of technical points, or (e) inability to interact directly with the prospective user. The author suggests three areas where possible research would appear to be productive: (1) To study in detail the information sources used by federal buyers in both routine purchases and new buys to determine more sharply the similarities and differences to organizational buying. Research procedures and methodologies similar to those employed in organizational buying would be employed to facilitate comparison. (2) Comparative buying study between Government and industry on a number of commodities purchased by both. (NOTE: Some studies of this type have been conducted by the Defense Logistics Agency). (3) Undertake a buying experiment in which certain commodities would be acquired under modified (more flexible with regard to information sources) purchase procedures. Comparisons of buying performance would be made with other regions/ departments following current procedures.

A research paper by a professor of management (23) conceptualizes the acquisition process of organizations by a presentation of the various "schools of thought" concerning conceptual models of the acquisition process of organizations. The author develops a managerial perspective of the models from the viewpoint of both the marketeer and the acquisition practitioner. He presents the emerging strategic management approach to the acquisition process, with emphasis upon strategic management of resource market relationships which have implications for acquisition managers. The five "schools of thought" are presented through three main organizational perspectives brought in by operational settings: (1) the materials management perspective of practicing buyers in commercial organizations; (2) the organizational buying behavior perspective of practicing marketing managers; and (3) the acquisition management perspective developed by the Federal Government.

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23. Schill, Dr. Ronald L..

The author develops a conclusion that Government and commercial organizations face the following needs in the 1980s as a result of the emerging trends in acqusition management;

-- Improved conceptual/strategy skills and capabilities of acquisition managers, including better capabilities at industrial marketing analysis and other conceptual tools to view their resource markets.

-- Improved educational opportunities for mid-career and high level managers who will fill top acquisition management functions.

-- Research aimed at determining the level and content of effective and ineffective management actions of the acquisition function, specific needs for improvement, and a better understanding of resource markets as industries.

-- Increased research at modeling strategic aspects of the acquisition function and formulation of research hypotheses.

The author invites persons who are interested in a broader, more detailed, conceptual example of modelling issues than are presented in his paper, to consult his references and to get further reference material from him.

A research paper by an Army procurement researcher (24) analyzes the significant similarities and differences between Federal and other organizational buying. The paper points out constraints peculiar to Federal buying is a special case of organizational buying, constrained to a certain set of techniques, and that much of the organizational buying literature and practices can be useful for the Federal buyer. The one constraint that appears to be dominant and is the basis for most of the differences is that of legal requirement. The Federal buyer is using everybody's money and is buying things in the name of everybody. This requires that every action be just, equitable, visible and answerable to every citizen. These requirements constrain every Government buyer. The organizational buyer is using private sector money, buying for the firm and limited in technique only by his boss, the Uniform Commercial Code, and anti-trust law. Today's Federal programs to "buy commercial", "contract out", and use non-restrictive specifications are cited as compelling recognition of the closing gap between Federal and other organizational buying. The author concludes that both groups must take advantage of the cumulative knowledge of the other and exchange research findings. More research in organizational buying is recommended.

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(24) Williams, Robert F..

A research paper authored jointly by an industrial acquisition researcher and the Government project manager (25) reports on a study of Air Force acquisition of commercial derivative aircraft, contract logistics support for those aircraft, and the acquisition of a major item of support equipment. To achieve maximum benefits of Federal and DOD policy in Acquisition and Distribution of Commercial Products (ADCoP), the need is to get Government contracting requirements and procedures in harmony with marketplace practices in buying commercial products. This research was conducted to determine which provisions and requirements imposed in Air Force acquisition and logistics support contracts for typical major commercial systems and products, not imposed in typical commercial sales contracts, have a cost and schedule impact and, where possible, the extent of the impact. Analyses were made to ascertain the necessity for these provisions and requirements and to develop recommendations concerning their use in future Government contracts to buy commercially developed products. As a result of the research it was determined that one of the biggest drawbacks to the Government acquisition of commercial aircraft, aircraft modifications and contract support is the practice of including a large number of general provisions in the solicitations and subsequent contracts. Where they are required to be included in subcontracts for commercially produced items, flow down is exceptionally difficult because of questionable applicability. The research report contains recommendations for changes in the Defense Acquisition Regulations (DAR) and in the new material being developed for the Federal Acquisition Regulation (FAR) to correct these deficiencies. Additional recommendations include using commercial standards and practices where the cost of modifications represents less than 35 percent of the price of the basic product, and the elimination of other unnecessary documentation of practices in any event.

17. Procurement Methodology.

A research paper by a professor of business administration (26) reports on recent research conducted concerning the process and criteria used in selecting contract types for major acquisitions. The principal technique employed in the research was unstructured personal interviews during which the interviewer suggested particular topics. Data was collected independently from nine different Government or contractor organizations, against a common set of instructions which included eighteen contract types. From the interviews conducted, the researcher proposes seventeen criteria pertinent to contract type decisions. The criteria selected are: (1) Current State of the Art; (2) Current Stability of the Technology; (3) Nature of the Contract Specifications; (4) Program Objectives; (5) Program Importance; (6) Program Stage; (7) Duration; (8) Motivational Factors; (9) Past Performance of Contractor; (10) Legal Constraints; (11) Production Potential; (12) Contract Management

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(25) Ostrowski, George S.; Lockwood, Major Lyle W..
(26) Sherman, Stanley N..

Complexity; (13) Independence of Action During Performance; (14) Administrative Costs; (15) Use of Government Furnished Property; (16) Availability of Cost and Pricing Data; and (17) Accounting System.

A research paper on the underlying theory behind incentive contracting, authored by a professor and a former Government acquisition researcher (27), suggests the application of motivational factors other than profit. The paper reviews the economic and management literature to determine the relationship between the profit maximization orientation of firms, other motivational factors and the incentive contract. The authors conclude that since profit is not the only theoretically correct objective of a firm, it is important that Government attempt to "top other goals" in the acquisition process. Other motivational factors are suggested. It is also offered that as the Government attempts to meet these non-profit goals, the overall costs of the contract might be lowered since profit is not exclusively relied on to motivate the contractor. The authors suggest a more balanced approach to Defense Acquisition Regulation (DAR) profit policy.

A research paper on Award Fee contracting applications in the Air Force Systems Command (AFSC) describes a 15 case study (28). Interviews were conducted with both Government and contractor personnel. From these reviews, empirical descriptions of patterns of award fee were generated and analyzed. Seven issues are recommended for either or both policy review and research. The author also identifies three major defects which need to be remedied and recommends training to orient or re-orient award fee contracting policy to emphasize simplicity, subjectivity and flexibility. The first major defect is that award fee evaluation plans too often are too elaborate. "Simplicity" rules of thumb are routinely violated by excessively large numbers of evaluation factors and complex methods which even their users frequently cannot understand. The second defect is related to the first. The author finds that award fee planning and administration typically suffers from "objectivist" biases which subvert the award fee as a means of effecting subjective evaluations of contractor performance. They tend also to decrease the ability of Government managers to control the programs for which they are responsible. The third major defect is "bureacratization". The danger of this or standardization is that it inhibits flexibility and discretion in environments (like R&D) where flexibility and discretion are essential to effective management. The author emphasizes the need for training to correct these defects rather than further development of award fee contracting manuals. The training is needed in basic concepts and strategic objectives and, especially, the facilitative functions of award fee for program management.

The results of a study of the "leader/follower" concept in acquisition (29) include identification of nine factors which affect the use of leader/follower and a decision model. The model is a sequential decision model

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(27) DeMong, Richard F., D.B.A.; Strayer, Daniel E.Ph.D.
(28) Hunt, Raymond G..
(29) Thompson, Charles W. N.; Rubenstein, Albert H..

presenting the initial decision of "whether or not to use" in a series of steps keyed to critical factors, followed by the second decision of "how to use it". Basic to the leader/follower concept is a decision to "second source", usually for one of two objectives: to achieve cost containment or cost savings through completing part or all of a large, extended production run; to achieve assurance of supply, either to meet a delivery schedule beyond the capacity of a single supplier, or to assure continued supply over an extended period. The decision to use leader/follower appears where it is both feasible and necessary to provide extraordinary manufacturing assistance and know-how to the second source from the developer/producer.

Research conducted to find an optimum contract for use in the acquisition of follow ships for the Navy (30) proposes a new approach using a combination of a Fixed-Price-Incentive (FPI) and a Cost-Plus-Award-Fee (CPAF) in a FPI/AF type contract to motivate a contractor in a follow ship setting. The basic structure of the contract is fixed price incentive with incentive features for cost only. However, interwoven into the contract are award fee features which encourage the contractor to provide superior technical, schedule, management and cost performance. The research paper gives specific examples of technical performance, schedule performance, and management performance factors which would be measured and judged. Cost factors which are to be monitored include basic cost performance and early cost problem identification and correction. Although a conceptual model, the paper describes the benefits of a Fixed-Price-Incentive/Award Fee (FPI/AF) contract for a follow ship with convincing rationale on the application to real world situations. Other applications and variants of a FPI/AF contract are included in a separate part of the research paper. The author recommends that graduate students and other procurement researchers look in detail at such applications and variants as a necessary step in broadening the state-of-the-art in contracting for important weapon systems of the future. Comment: The time required to test these kinds of research models is quite long. Testing the total model would require a piece-meal approach.

A research paper on second sourcing in major system acquisitions (31) discusses five methods which can be used to provide two or more sources for production of a weapon system. One of these is leader/follower. The others presented, which are not to be considered as being all inclusive, are: form-fit-function, technical data package, direct licensing and contractor teams. The major objectives of the research were to (1) delineate the potential reasons for second sourcing; (2) develop a description of the methods available for generating a second source; (3) identify the factors involved in evaluating the feasibility of second sourcing a given acquisition; and (4) formulate a model to assist the Program Manager in selecting the most appropriate second sourcing methodology. The Second Sourcing Method Selection Model (SSMSM) developed uses 14 decision variables and a simple three point system to denote whether a given one of the five methods is particularly strong, neutral or weak.

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(30) Meiners, Dr. Arthur C., Jr..
(31) Parry, LCDR D. S., SC, USN; Sellers, LCDR B. R., SC, USN.

The major steps in a cost comparison study and "contracting out" for goods and services are detailed in a research paper (32) authored by the Government personnel involved in the utilization of commercial resources to manage and operate the Standard Base Supply System (SBSS) at Patrick Air Force Base, Florida. The research paper references a document which supports the paper, "Major Steps in a Cost Comparison Study - Contracting Out for Services at Patrick AFB, Florida". That 500 page report which details the 42 major steps involved in this case is available to qualified Government personnel and to researchers on this subject, through the Air Force Business Research Management Center. In addition to complying with OMB Circular A-76, compliance with Air Force Manual 26-1 is documented. The research paper lists the major difficulties encountered which dealt mainly with relocation of personnel and contending with the socio-economic controversy. The "lessons learned" included: (1) Establish a highly qualified individual/functional staff to implement the contracting out study. (2) Obtain firm commitments from displaced Government employees as to whether they will or will not accept employment with the winning contractor. (3) More detailed criteria should be provided in AFM 26-1 in order to more efficiently perform a Cost Comparison Study. (4) Allow adequate time and recognize costs for contractor phase-in. The authors recommend additional research and detail how it should be performed. The end result of the study would be model contracts and statements of work for the different "types" of activities.

A research paper reviews the changes in defense spending as a percentage of the Gross National Product (GNP) and analyzes its impact on both defense programs and on the decline in the number of contractors willing to undertake major military programs (33). A study of the Aircraft Landing Gear industry is used to illustrate the effects of declining requirements and intense competition. Only three contractors are currently producing the product. Also, as resources have become more scarce and military requirements more complex, prices and manufacturing leadtimes have grown at an astounding rate. The author cites the potential advantages of multiple-year contracting to both the Government and the contractor. However, he recommends the lifting of the present $5 million cancellation ceiling to an amount more reflective of the present burden being assumed by the contractor. In today's environment, most prospective contractors realize that such a low ceiling will cover only a very small portion of the sunken costs initially required to begin production. The cancellation ceiling, in effect, is forcing contractors to "buy-in" during the early production period. The threat of cutbacks or even complete cancellation is ever present. This situation has had an adverse impact on production leadtimes. Projects must be either dropped completely or the acquisition cycle is lengthened making the final product more expensive. Lifting the cancellation ceiling should foster more realistic program planning and budgeting.

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(32) Guy, M. Kathy; Overall, Colonel Douglas, USAF.
(33) Briggs, R. L..

Another paper presents the findings of research conducted on the quantity, causes and impacts of wasteful year-end spending in the largest civil agency (34). To preclude the annual recurrence of this negative influence on effective management of acquisition, a model of advance procurement planning paralleling budget priorities in anticipation of various funding level has been developed and is presented. The model demonstrates procurement planning as a logical outgrowth of a proper budget formulation process. The major departure from previous attempts in this agency to control year-end spending is that it places the accountability for management and long range planning of program requirements with agency heads and project officers who are involved in the front end of the acquisition process rather than with contracts personnel who have little control over the timing of project identification and definition. If the system is implemented effectively, it offers great potential for savings by scheduling adequate time in the acquisition process to accurately define Government requirements, obtain competition, prepare thoroughly for negotiations and issue clear and enforceable contract terms. The model should be adaptable to other agencies.

18. Contract Pricing.

A comprehensive paper on DOD Profit Policy (35) traces the evolution of that policy, with emphasis on recent changes published in Defense Acquisition Circular (DAC) 76-23, 26 February 1980; reviews empirical data on negotiated profit rates and contractor facilities capital investment; and identifies some remaining policy issues. The policy issues under active consideration by DOD include:

-- Appropriate revisions to the productivity reward profit factor. This factor has not been used to the extent originally envisioned. DOD is seeking ways to simplify the criteria for its use. The problem with productivity is similar to the problem which existed with capital investment ten years ago--there is no generally accepted definition and means of measurement.

-- The profit factor for independent development needs to be clarified. There is confusion of this factor with IR&D, when its intent is to provide additional profit when acquiring items that were independently developed.

-- Actions need to be taken to minimize the inertia in the system with respect to profit policies. Contract changes and modifications adding new work and ceiling priced options subsequently negotiated at the same profit level as the basic contract will blunt the thrust of recent profit policy changes unless the current policy is made applicable to these types of contractual actions.

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(34) Cavanagh, James; Tychan, Terrence.
(35) Jacobs, Grady L.

Current economic conditions are such that there is reasonable doubt as to whether the return provided on facilities capital investment is adequate to motivate additional contractor investment. From discussion not a part of this research paper but related to it has been the suggestion that further research is needed relating to the cost of money environment, suggesting an examination of possible changes to progress payments and/or adjusted profit level considerations. Interest rates now far exceed normal profit levels. Prior years' profits were twice interest rates; now they are almost one-half.

An on-going research paper on the effectiveness of profit negotiations in the promotion of contractor efficiency (36) advances the premise that the Defense Acquisition Regulation (DAR) requires that profit dollars should be negotiated in such manner as to drive a firm to efficient as well as effective performance and that effective performance is not necessarily efficient performance. "Should Cost" analyses have given evidence of in-efficiencies. The paper further contends that major non-competitive production acquisitions have three salient characteristics which encourage inefficiency. First, the acquisition is conducted in a monopolistic situation. Second, the buyer cannot act as a monopsonist because of the relative inelastic demand. And, third, the negotiated profit ranges are narrow and relatively fixed from one acquisition to another for the same item. The study will analyze negotiated profit rate data on non-competitive acquisition for FY 75 through FY 79 to determine if, in fact, there is a predetermined narrow profit range. The analysis will attempt to discern any impact the implementation of profit policy may have on a contractor's efficiency. It is anticipated by the author that the analysis will lead to recommended policies that would encourage performance efficiencies.

A research paper on Economic Price Adjustment provisions (37) advances the theory that continued use of escalation provisions without careful consideration does not encourage contractors to apply efficient and effective management tools to minimize the effects of inflation. The researchers showed that it is possible to estimate inflationary price increases with some degree of certainty, and that the use of economic price adjustment clauses should be limited with more reliance being placed on forward pricing techniques.

A research paper on the estimation and analysis of Navy shipbuilding program disruption costs (38) reports a test of the feasibility of statistical methods for fully pricing shipbuilding change manhours. It was illustrated that the dynamic nature of the acquisition process calls for the development of innovative pricing techniques to meet the changing conditions. In the opinion of the researchers, these statistical methods could be applied with even more precision and confidence using data gathering systems designed explicitly for estimating change costs. They believe this methodology holds considerable promise for fully pricing changes in future shipbuilding.

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(36) Nick, Robert W.
(37) Herington, David L.; Kalal, Gerald W..
(38) Hammon, Captain Colin; Graham, Dr. David R..

19. Competition.

A research paper on the enhancement of competitions in the Department of Defense (39) reports on a comprehensive study of DOD's acquisition/purchasing/contracting regulations policies, and procedures to provide recommendations for increased price competition. In addition to random sampling of data in all of the services and interviewing the buyers and contracting officers involved, methods of motivating Government personnel and of eliminating any real or perceived impediments to price competition were sought. Although the research was on-going at the time the paper was prepared, it includes some of the recommendations made to DOD.

Another research paper on competition in the Department of Defense (40) examines the circumstances which structure the environment for DOD acquisition. The concept of competition, market structure, contract placement methodologies, the competitive environment, and current research results as they impact on competitive conditions are reviewed and analyzed. The paper concludes that competition does seem desireable in terms of reduced cost for goods and services but there does not seem to be any single technique that will insure competitive buys. Research results indicate that the basic mechanisms exist for the injection of competition into the acquisition process; the key seems to be reliance on the competitive market and the application of judgement to the areas of acquisition planning and control to insure that the system works in the most beneficial way possible.

A research paper on the evaluation of competitive alternatives for weapon system production (41) describes a model which applies to the multi-period production of systems for which high costs of introducing and sustaining competition offset the effect of the competitive forces. The model includes the effects of learning, capacity constraints, and costs of layaway, reactivation, start-up, direct production, etc. The strategies available include sole-source, full competition or limited competition. The author recommends additional research to better define and quantify the mechanism by which competition exerts its influence on weapon system costs. He recommends that future work focus on this empirical documentation of the effect of competition.

A methodology for forecasting savings from repetitive competition with multiple (split) awards is presented in another research paper (42). The study addresses the condition in the acquisition cycle when program managers and contracting officers must decide whether or not to compete the remaining quantities of a weapon system. There can be substantial one-time costs to introduce competition, and there can also be savings in unit price. The study considers the possibility of multiple (or split) awards, and also considers repeated competitions for the same item. A sample of 22 ammunition acquisitions was selected for analysis. In this sample,

(39) Unruh, Daniel D..
(40) Martin, Colonel Martin D.; Golden, Major Robert F..
(41) Smith, Charles H..
(42) Brannan, Richard C..

the competitive savings achieved in later acquisitions is approximately the same as the savings achieved in the first few acquisitions for the same item, a finding that the author believes should be verified in future studies. A useful rule of thumb developed is that competition with split awards reduces the unit price of ammunition items by an estimated 7 percent. The term "ammunition" includes bombs, fuzes, projectiles, cartridge cases, warheads and other items. This 7 percent figure can be used in a tradeoff analysis to determine the economic effects of introducing competition, which in some cases can require large one-time costs.

Another research paper describes a procurement strategy for achieving effective competition while preserving an industrial mobilization base (43). The paper is based on an actual case where only two companies were qualified to produce a sophisticated night vision system. One company had been the development contractor and had had production contracts. The second company was the alternate source established to provide competition and an industrial mobilizations base. Before the solicitation was issued, a mathematical equation was devised that could be used to determine the proper split of the quantities based on the difference between their proposed prices. A conclusion of the research was that the simple technique of splitting a procurement quantity between two or more producers based on a fixed ratio (e.g. 60 percent vs 40 percent) is often ineffective and inequitable. However, by developing a functional relationship between the proposed prices and the split of the total procurement quantity, effective competition can be introduced in a controlled manner. Management can then strike an optimal balance between the benefits to be derived from competition and the benefits to be derived from an industrial mobilization base.

A paper on predicting the costs and benefits of competitive production sources (44) presents the results of an acquisition study performed to develop a methodology for predicting the net savings in production costs due to competitive, dual source production of the cruise missile, as opposed to sole-source production. The paper details the theoretical concepts underlying the methodology, discusses the data base which was used for estimating the parameters in the model, and presents illustrative results. The authors conclude that although numerous studies have attempted to estimate the impact of competition on weapon system production costs, the results have not been completely reliable. Additionally, the distinction between evaluating the past impact of competition and predicting its impact on future programs was not properly drawn. In this case, the authors have constructed a theoretical model which could be used predictively. However, the data were not available except in one previous study so it was necessary to draw conclusions from an inadequate data base. However, since the model was constructed to perform sensitivity analyses, production cost estimates can be obtained for a variety of assumptions, and confidence limits can be established.

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(43) Solinsky, Kenneth S..
(44) Drinnon, J. W.; Gansler, J. S..

E. PROGRAM/CONTRACT MANAGEMENT

20. Program Management.

A research paper on Joint Service Acquisition Programs (45) based on the Guide for the Management of Joint Service Programs, prepared under the sponsorship of the Joint Logistics Commanders, addresses the lessons learned uncovered by this research on joint service programs and how joint programs differ from single-service programs. The objective of this study was to identify and analyze the most common joint service acquisition problems. The approach consisted of a literature survey and personal interviews with sixty-seven joint service program managers and their program staffs, as well as, service and OSD staff members involved in joint program acquisition policy formation. The paper includes conclusions and recommendations important to the success of a joint program. Paramount among these is that nothing is more important to the success of a joint program than interservice agreement on requirements or funds. The agreements may need to be consumated at the service headquarters level since it is here requirements are validated and funding priorities established. Methods and structures to resolve service conflicts over requirements and priorities are needed. Another important point made is that Logistics Support Analysis (LSA) deserves the highest visibility within the joint program office to tie together the elements of the integrated support to a common data base. The Standard Integrated Support Management System (SISMS) must be instituted as early in the program as possible. Finally, and most importantly, micro-management must be avoided. The need to resolve requirements and funding issues at the service headquarters and OSD levels can quickly and even inadvertently lead to incursions into the program manager's domain. These must be avoided if program management integrity is to be preserved.

One research paper presents a theoretical description of an extremely simplified example of the acquisition of a new ASW system (46). Using this simplified example, the paper outlines how implications and conclusions may be drawn from a quantitative theoretical model that can be helpful to the acquisition manager in formulating acquisition strategy in the real world. In summary, the paper suggests that the development of an acquisition strategy early in the process can be facilitated by: (1) recognizing that the acquisition process is fundamentally a decision process that requires the collection and structuring of information for making choices; (2) structuring a "top tier" decision model as a basis for integrating objectives at all levels of the entire project as a first priority task; and, (3) formally quantifying the assumptions and decision criteria used throughout the process which can be checked against actual results obtained downstream in the project.

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(45) Fargher, John S. W., Jr..
(46) Atkinson, A. S.,

A multi-criteria planning aid for defense systems acquisitions is presented in another research paper (47). The Multiple Criteria Decision Theory (MCDT) presented is a combination methodology based on the complementary characteristics of the Multiple Attribute Utility Theory (MAUT) and Multiple Objective Optimization Techniques (MOOT). A set of criteria which can be used to evaluate, in a comprehensive manner, alternative system configurations is presented and used, with synthetic data, to illustrate the proposed planning aid.

A companion research paper (48) recommends the application of system engineering techniques for a more effective approach to decisions involved in developing and procuring DOD systems. The study addresses the possibility of developing a systems-engineering methodology to support the systems-acquisition decision process. The emphasis of the study is directed toward the four major DSARC and (S)SARC decision milestones and the use of the Decision Coordination Paper (DCP) and Mission Element Need Statement (MENS) within the overall DOD policy framework. The nature and the structure of the decision process provide specific areas where a systems engineering methodology could be applied most beneficially. After the criteria for choosing the appropriate systems engineering tools and techniques are established, a methodology is developed with specific analysis procedures which are dependent on the stage of the acquisition process and the nature of the decision under consideration. A systems engineering team with specific functions and characteristics is suggested as a means by which the methodology is implemented.

The computerized program planning and management system being used in the management of space programs is presented in another research paper (49). The Program Planning and Management System (PPMS) was developed for use in direct support of the Director of a Multi-Program System Program Office (SPO) in the Directorate of Advanced Technology in Headquarters, USAF. The PPMS, as presented in this paper, is a description of how to establish and manage a successful system program acquisition. The PPMS concept is built upon the premise that the primary duty of a System Program Director (SPD) is to make decisions. PPMS is designed to provide the proper mix and granularity of programmatic, technical, cost, and schedule information for SPD decision making. The PPMS computer system uses the Hewlett-Packard 9830B with mass storage, line printer, plotter, and the CRT for data input. Identical hardware and software is provided to the SPO program control office and to each of the major contractors. PPMS is designed to be extremely flexible, without a predefined hierarchy, so that by using plain English descriptive titles a program breakdown structure would automatically be constructed. The research paper includes illustrations of worksheets, computer printouts, etc. Inspite of the PPMS capabilities and how they are used in managing a major space program, the focus is strongly on PPMS supporting the SPO management process.

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(47) DeWispelare, Aaron; Sage, Andrew P.; White, Chelsea C., III.
(48) Roesch, Maurice; Sage, Andrew P..
(49) Jacoby, Major James E., USAF.

A study on accelerating the decision process in major system acquisition (50) had an original objective of ascertaining how the management review process incident to DSARC milestone decisions affects the length of major system acquisitions and to determine what changes are needed in this process to accelerate major system acquisitions. Of the 13 programs reviewed, only 2 were adversely affected by the DSARC management review process and these delays were minor and related to the issuance of the actual SecDef decision. It was found that the management review process tends to parallel the technical development of the system and its length is a function of the chain of command within the reviewing organization. It was concluded that the DSARC management review process does not have a significant impact on the length of the major system acquisition cycle and recommendations on specific steps or aspects of this process are not warranted. The author suggests that further examination into areas such as funding problems, testing requirements and concurrency may prove useful in shortening the acquisition cycle.

A new concept for managing the contract award process is described in a research paper (51) which proposes network analysis for modeling and simulation to develop contracting performance measurement systems. The principle advantage in the technique proposed is that peculiarities in the contract process are considered and each contract actually has its own standard based on the complexities encountered rather than rigid management performance standards.

21. Productivity.

Productivity improvement through incentive management is proposed in a research paper (52) based on an anlaysis of 54 cases in which incentive management strategies were tested and the consequences measured. The results confirm the utility of incentive management techniques in a wide range of work place situations but suggest that incentive strategies must be tailored to the specific work context to optimize productivity outcomes.

A research paper on work simplification technology as an acquisition parameter (53) presents the progress to date made on making methods studies where the computer is coupled to video tape recordings (VTR) to provide a modern day analysis tool. In the paper the authors have brought together the concepts of productivity, the control function of management and the work measurement area of industrial engineering. The equipment in development to adapt video tape recordings to digital computers could be of significant value to the simplification of certain acquisition functions. The investigation of these functions with the focus on cost reduction is an area of potentially large savings and, in the opinion of the authors deserves further analysis by acquisition function managers.

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(50) Moeller, William G..
(51) Huber, Major Robert A., USAF; Vitelli, Captain James, USAF.
(52) Spector, Dr. Bertram I.; Hayes, John J., Major General USA (Ret).
(53) Daschbach, James M., Ph.D.; Henry, Eugene W., Ph.D..

A paper on productivity improvement among Federal employees (54) describes a research program designed to improve the individual productivity of small purchase buyers and supply clerks at a Naval shipyard. The study was conducted as part of the Defense Integrated Management Engineering Systems Program (DIMES). A Performance-Contingent Reward System (PCRS) has been established which preliminary findings indicate is having a positive effect on productivity. Similar wage incentives are used by industry.

A manual on planning and production control for shipyard use is the basis for a research paper on production oriented planning (55). The program seeks to improve productivity and thereby reduce differential subsidies in commercial ship construction. The paper is a summary of the planning and production control manual published as part of the National Shipbuilding Research Program. The manual is really a primer for supervision to give them an overall view of the total ship process. It has value as a role building technique.

A comprehensive paper on improving the acquisition system (56) is presented as a proposal to apply some of what is already known "to bring the acquisition system under control and to rationalize its operation". The paper quotes some of the criticisms of the past decade and proposes a six-step process to make a complete revision of the acquisition system on a total system approach. (NOTE: Apparently because of the date this research paper was prepared, no reference is made to the Uniform Procurement System (UPS) being developed by the Office of Federal Procurement Policy (OFPP) under the provisions of P.L. 96-83. All of the material in this paper is included in the UPS project).

A research paper on production rate as an affordability issue (57) presents a rate/cost model based on empirical data. The paper proposes one method for estimating the rate/cost relationship based on empirical data points which are unique to each weapon system. Methodology for performing the analysis is explained and an example is given using a hypothetical aircraft program.

A research paper on the acquisition of non-nuclear munitions (58) describes a study conducted to find a way to reduce the time required for full scale development and transition into rate production. The time span from idea (Milestone 0) to first delivery was taking as long as 13 years. The study identified six primary areas requiring improvement. Some of the recommendations have been implemented. Overall results are encouraging and indicate a definite advancement in the way the Air Force does its munitions acquisition.

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(54) Nebeker, Delbert M.; Shumate, E. Chandler.
(55) Robinson, Rodney A.
(56) Massey, Dr. Robert J.; Smith, Gordon A.; Witten, Jack T..
(57) Bemis, John C..
(58) Wolniewicz, Lt Col. Peter F., USAF.

A research paper on production readiness (60) reviews the progress one year after the issuance of DODI 5000.38, 24 January 1979, requiring Contractor Production Readiness Reviews prior to DSARC III. This research concludes that the DODI should address the existence of the concurrent effort and data from Should Cost, Design-to-Cost, determination of Contractor responsibility, and producibility engineering and planning efforts. The paper recommends that the Deputy Under Secretary of Defense Research and Engineering (Acquisition Policy) should examine the feasibility of developing one DOD instruction which deals with the entire subject of major weapon system contractor reviews to identify overlapping policy and efforts. By capturing all reviews, the overlapping evident from this research can be eliminated.

A research paper on manufacturing technology investment strategy (60) details approaches being developed by the Air Force Systems Command to enhance the productivity of defense contractors' industrial base. Emphasis is placed on maximizing the effectiveness of the Air Force Manufacturing Technology (MANTECH) Program as a cost reduction and productivity enhancement technique. The Manufacturing Technology Investment Strategy Task Force was about half through the data collection and analysis portion of the effort at the time the paper was prepared and no results are available from this on-going research.

A production decision framework for making work force level and inventory planning decisions is described in another research paper (61). The research effort was directed toward the development of a dynamic method for solving the aggregate planning model. Emphasis was placed on developing a logical, understandable, and straight-forward model. The areas requiring future research are specified.

An assessment of a unique validated drawing program in a ship acquisition program is described in another research paper (62). The study documents the validated drawing concept and its worth and applicability to future ship acquisitions. The author states that it would be highly desirable to know the potential costs and cost savings and realistically, the cost savings expected can only be partially determined. The savings for elimination of duplicative design efforts can be estimated. However, the major savings - those coming from the improved efficiency resulting from the utilization of proven drawings - cannot be estimated. Such an estimate would amount to a judgment as to the savings from mistakes not made. In view of this fact, recommends that no attempt at cost/effectiveness analyses be made in assessing the applicability of validated drawings to future ship acquisition programs. In lieu thereof, the benefits and disadvantages of alternative ways of providing reliable detail drawings to follow shipbuilders should be weighed against those of the validated drawing concept without attempting to establish cost/effectiveness criteria.

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(60) Boyd, Major George V., III; Anderson, Joseph B..
(61) Holt, Jack A..
(62) Collins, John T..

Four specific recommendations for minimizing potential problems associated with future programs are included in the research paper.

22. Product Assurance.

A managerial analysis system for management and quality assurance is presented in a research paper (63) designed to improve understanding of the industrial process and provide a framework for making key program decisions. The Managerial Analysis System for Manufacturing and Quality Assurance (MASMAQA) is presented from the perspective of the program management office. The paper concludes that the proposed system can provide all industrial management personnel in each level of the hierarchy a common frame of reference for communication and can facilitate effective utilization of limited government industrial management personnel. In the long run, it may even permit identification of "reasonable" costs.

The Quality Horizons Study conducted by the Air Force Systems Command is presented in a comprehensive research paper (64). The study was prompted by a combination of several major and costly quality problems, advancing technology, and a significant reduction in the quality assurance workforce. The study team, consisting of six personnel with experience in quality, reliability and contracting, visited 66 government agencies and industrial firms in the United States, Japan, Germany, Denmark, Norway and Belgium. The industrial firms visited were engaged in work involving total commercial, total defense, or a combination of the two. The major areas of review were: quality planning, quality measurement, organization/manning, education/training and contracting techniques. As a result of the study, a new organization is being established as the Assistant for Product Assurance headed by a Senior Executive Service level civilian reporting directly to the Commander. Other actions initiated include: (1) Product Assurance will receive much greater attention during the early acquisition phases, (2) the Quality Assurance workforce will be enhanced and upgraded, including an intern program producing 25 graduates per year, (3) a formalized training program for journeymen will be established, (4) a career development program will be established, (5) curricula for courses for top managers will be reviewed to determine whether there is sufficient coverage of product assurance management, and (6) several contracting approaches to enhance product quality have also been approved.

A paper on productivity assurance in systems acquisition (65) describes a concept, derived from the existing Quality Assurance concept, being implemented at the Air Force Electronic Systems Division. Productivity Assurance is defined as a pattern of planned and systematic business management actions which provides confidence that the use of capital, technology, energy and manpower resources will result in a system or equipment capable of being economically produced. It is specifically

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(63) Martin, Colonel Martin D.; Lockwood, Major Lyle W..
(64) Epstein, Ira J..
(65) Orphanos, John A..

intended that Productivity Assurance be accomplished through the management efforts of development and production contractors in accordance with appropriate contract terms and conditions. Under this concept, it would be required that all major development and production phase contracts include a specific requirement for Productivity Assurance in the statement of work. Experience has already indicated that the implementation of the concept will require the support and coordinated efforts of Program Managers, Manufacturing, Contracting and other concerned functional elements.

Another paper relates quality incentives to the role of the Government's procurement quality control function in today's rapidly changing technology (66). A case is made for quality control of the individual characteristics at the point of manufacture, rather than "statistical" quality control. Measurement of these characteristics at the point of control is far more significant than is a lot-by-lot or an inspection after an accumulation of parts. Unacceptable parts or assemblies, delivered under the present inspection by statistical rules tend to decrease military readiness and give a false picture of stock ready for use. Costs for scrap, rework or re-acquisition of replacements are non-productive. The so-called "cost effective" systems that deliver defects using AQLs must be re-examined to include defect replacement costs as part of the original formula for the acquisition, and incentives for quality must be given at the point of manufacture of the "characteristics" of the parts. The paper describes and makes its case using a complex financial incentives system used on a re-entry vehicle program. Proper planning for the change in emphasis on control point incentives, as recommended in this research paper, would also require new looks at the qualifications and functions of Government Quality Control Representatives. (NOTE: Although implemented on the program described, this system has not been tested.)

The results of a study to investigate and develop concepts and guidelines for applying warranty-guarantee plans to ground electronic equipment is presented in a research paper (67). The guidelines were designed to assist program managers in selecting and properly evaluating candidate ground equipment acquisition programs so that the warranty-guarantee plans can be structured, implemented and effectively applied. The recommendations include a caution that the final decision to use any form of warranty-guarantee for the acquisition of ground electronic systems should be based on an economic analysis using a life-cycle-cost (LCC) model, during the evaluation of contractor proposals.

A research paper on models for analysis of warranty policies (68) compares a number of models that have been developed for analysis of warranty costs. Consumer, commercial and military warranties are included. Their similarities and differences from both the buyer's and the seller's

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(66) Theede, Edward.
(67) Crum, Fred B.; Fiorentino, Eugene.
(68) Blischke, Wallace R.; Scheuer, Ernest M..

viewpoint are discussed. The paper looks at warranty structures (terms, conditions, etc.), and presents economic and statistical models in some detail. The primary military warranty considered is the Reliability Improvement Warranty (RIW).

Another research paper on warranties (69) describes the KC-10 warranty and service life policy and the background leading up to its use under the basic philosophy of the program to use commercial practices to the maximum extent possible. With minor modifications to accommodate the KC-10 program and its proposed utilization rate the Douglas' Commercial "Warranty and Service Life Policy" is included in the Government contract. The research paper summarizes the lengthy and complicated commercial provisions covering: what the warranty covers, what defects are covered, billback provisions, customer compliance provisions, vendor warranties and specific engine warranties. In addition to the basic warranty, the contractor provides additional coverage of selected components (e.g. airframe components, landing gear components) through his service life policy. The KC-10 program is unique from the standpoint that the aircraft will have contractor logistics support and, in this case, the same contractor has both contracts. This dual role gives them added responsibilities under the two contracts.

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(69) Chalecki, Ronald R.

F. ACQUISITION LOGISTICS SUPPORT

23. Logistics Support.

A technique for improving the effectiveness of the Logistics Support Analysis (LSA) process is presented in a research paper (70) which describes an analysis technique designed to provide maximum resource identity at minimum analysis cost. The technique ranks a set of Functionally Significant Items (FSIs) in a manner that will predict resource requirements, project manpower requirements and assess the impact on equipment operational ability. The paper states that at present there is no technique to cope with the sometimes complex problems associated with an effective Integrated Logistic Support (ILS) program and that the need exists for a simple LSA technique and a simple and efficient feedback system. The methods and basic reasoning used in the development of a prioritization technique are presented. Recommendations are provided to maximize the benefits inherent in the prioritization concept.

Another research paper (71) describes how to avoid costly pitfalls of redundant documentation for high reliability parts by applying parts control techniques in the early phases of equipment development. The authors describe new standardization techniques to prepare accurate documentation within shortened schedules. The parts control system described is largely oriented to electronic systems and has been in use at the Defense Electronics Supply Center since 1972. Life cycle cost avoidances accrued are estimated to be in excess of 600 million dollars. The technique is also being applied in other areas by other DLA Centers.

Affordable automatic testing is the subject of another research paper (72) which describes the Modular Automatic Test Equipment (MATE) Program established by the U. S. Air Force. Two MATE program contracts were awarded to industry to identify specific problems and a systematic approach to overcoming these problems. The surveys are both completed and the contractors are currently verifying the approaches they will recommend. The paper also discusses the Automatic Testing Study Plan of the Joint Logistics Commanders' Panel. The research paper concludes that the service cannot afford to address the requirements of each weapon separately and that the management of automatic test equipment must be consolidated to assure more economical testing. This will be done through the MATE program and its interface with the Joint Services effort. An annual Joint Service Automatic Test Review is planned to provide inter-service communication concerning accomplishments and future plans.

Several other research papers in the logistics area presented at the Symposium contain information, models and research results. They are listed in the reference section (73, 74, 75).

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(70) Davis, George R..
(71) Swanson, Donald K.; Gastineau, Charles E..
(72) Henscheid, Lt Col. Robert; Long, Captain Floyd D., Jr.; Martisaukas, Captain Algio J..

24. Procurement Automation and MIS.

A special feature of the Symposium included live demonstrations of Procurement Automation systems by the Departments and Agencies who developed and/or are using the systems. Demonstrations included:

-- Headquarters, DARCOM, Procurement and Production Directorate presented their Procurement Automated Data and Document System (PADDS). This system utilizes a computerized data base in a distributive processing mode. It automatically produces documents such as solicitations, contractual documents, modifications and various management reports.

-- The Department of Energy displayed their "Auto Preps" system which automatically generates contract documents. They also demonstrated their Integrated Procurement Management Information System (IPMIS) which tracks the major activities in the procurement process from initiation to file retirement.

-- The General Services Administration, in cooperation with the Department of Commerce, demonstrated an Electronic Mail application using GSA's Administrative Reporting System (ARS) to remotely transmit sample Commerce Business Daily (CBD) submissions to the Department of Commerce CBD office located in Chicago. GSA also demonstrated a remote terminal inter-active system for automatically generating delivery orders against GSA schedule type contracts.

-- The Defense Contract Audit Agency demonstrated their Advanced Audit Technique System (AATS). This system is used to manipulate contractor data in support of audit reports. It is also used for management tracking and control of internal workload.

-- The Air Force demonstrated their "Copper Impact" interactive remote terminal system. This system principally supports Pricing Offices and AFPRO Offices in their analysis of Contractor Cost and Pricing Proposals. Numerous cost models based on the Contractors Cost and Accounting Systems have been developed including a generalized cost model that is used by a number of other organizations including the Navy, Army, DoT, and NASA.

-- The Air Force Human Resources Laboratory demonstrated a variety of remote interactive computer applications including key word retrieval of the Defense Acquisition Regulations.

-- NASA demonstrated a remote terminal interactive system for tracking Purchase Requests, and a system for automatically generating Purchase Orders, delivery orders, and RFQ's. NASA also demonstrated colored computerized graphics using a large video display screen. This system illustrated the use of the computer to prepare a multitude of graphic charts that could be used by management to assess procurement performance intern of milestone tracking and commitment, obligation expenditures versus time.

-- The Small Business Administration demonstrated their Procurement Automated Source System (PASS). This system provides areas to a variety of information on small businesses in support of procurement solicitations by other agencies.

-- The Navy demonstrated an interactive computer system that automatically generates procurement documents, e.g., contracts and solicitation documents. This system also tracks these documents from preparation through contract administration.

A comprehensive investigation of the software requirements allocation process is included in a research paper (76) which analyzes the DOD and Air Force policies and procedures on requirements allocation. The allocation decision criteria were identified and evaluated, and the feasibility and potential impacts of an alternate methodology, called "Horizontal Allocation" were evaluated. Semi-structured interviews of government and industry "software experts" were used to collect the research data. The research paper includes a number of recommendations for a total system approach to the Computer Program Configuration Item (CPCI) process, the implementation of horizontal allocation on a medium to small sized program to establish empirical evidence that it is effective, and for additional research.

A "little" Acquisition Management Information System (LAMIS) is presented in another paper (77). The system is termed "little" to distinguish it from the USAF AMIS system. It was developed for and is used at the USAF's largest research and development contracting organization, the Aeronautical Systems Division's Directorate of R&D Contracting. It is a total contractual workload tracking which involves all phases of the contracting cycle from receipt of the purchase request to the ultimate closeout of the contract. It is a very flexible system. The reporting, tracking and data base are easily adaptable to any type of contracting.

A totally integrated management evaluation system is described in another paper (78). The paper presents a total cost relationship concept of analysis to be used by managers in making better decisions resulting in better utilization of resources. The concept is to be used in solving complex problems, giving better insight into cost relationships, developing a better information system, and a simple communication process for complex mathematical

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(76) Cooper, Captain Virgil L..
(77) Voss, John D. Lt Col., USAF.
(78) Schmidt, Frank L..

formulae. The basic concept presented is that the most demanding cost analysis review, with infinite cost variables, and infitite complexity, can be simply analyzed with the use of a simple concept and computers. The author presents a model of a totally integrated evaluation system.

A system designed to improve productivity in procurement through the use of automation is described in a paper (79) which presents the U.S. Army Materiel Development Command (DARCOM) Procurement and Production Directorate's automated procurement process. It is called the Procurement Automated Data and Document System (PADDS). PADDS utilizes a computerized data base that is designed to streamline and standardize DACOM's contracting functions. The system uses terminals and a dedicated mini-computer in a distributive processing mode producing documents such as solicitations, contractual documents, modifications, DD Form 350, procurement and production management reports, and transactions for updating files in DARCOM's Commodity Command Standard System (CCSS). Numerous payoffs are anticipated.

A review of the Federal Procurement Data System (FPDS) is included in a research paper (80) authored by a manager in one of the civil agencies. The author cites seven major obstacles to the success of the FPDS system, but predicts that the system can work and eliminate the time-consuming and expensive duplicative requests for data. Six significant changes required to be made to the FPDS are included and explained.

A research paper on the information system requirements of the acquisition community (81) details the Federal Acquisition Institute's (FAI) project to encourage research into the acquisition process and to provide a mechanism by which relevant information is conveniently made available to the acquisition community. Among other actions, the FAI tasked the Logistics Management Institute (LMI) to conduct a study of the categories of acquisition information users and to characterize the information of potential benefit to each class of user. The LMI user needs study served as input to the specification development process. Since acquisition practitioners function within dynamic environments, it is often not possible to define precisely the uses of information that may arise at some future point. This uncertainty affects both selection of data bases and the specification of processing which might become necessary. Consequently, an information system with limited capacity and flexibility may meet an initial design requirement but become unusable at some future time. It is important therefore to provide the greatest processing flexibility and capacity within the constraints of available resources. Three aspects of the functional requirement are pacing items. First, the data bases must be available over computer terminals to users located throughout the United States. Second, the software system must provide interactive search and retrieval services of essentially unlimited length textual documents. Third, the access should be to an apparently single, inclusive data base. The researcher discusses each of these aspects. The

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(79) Rogers, William J.; Begley, Clyde.
(80) Greenberg, Stephen J., Ph.D.
(81) Meigs, Daniel K..

FAI has no interest in physically developing and operating an information system. Rather, its basic strategy is to represent acquisition community interests with various providers of information retrieval services. If an integrated information system is constructed, a number of benefits might be expected to result. The FAI believes that implementation of these services would contribute substantially to integration of procurement knowledge, innovation within the process and, most importantly, to improvement of the efficiency and effectiveness of acquisition.

Another research paper (82) proposes Fourier Analysis as an analytical technique to be used in performance improvement in both industry and Government. The research includes a review of past use of the technique in studies conducted in an attempt to find a common denominator in the work of the Quality Assurance Representatives (QARs) in the Defense Contract Administration Services Region (DCASR), Chicago. In the current research reported the researchers used data from the work of engineers providing Technical Assistance on Cost Proposals (TACPs) and in the work of Price Analysts examining contractor's proposals. Additional research is recommended. Concentration in an industry or a portion of the Government could produce sufficient proof to allow design and implementation of programs which would yield a tangible payback in the very near future.

25. Financial Management.

Automation of program/project cost reports within the Department of Defense is described in a paper (83) which details how the Assistant Secretary of Defense (Comptroller) monitors the progress of major defense acquisition programs. A quarterly reporting procedure and analysis capability to track cost performance on major contracts is based on data provided to the Program Office in the Cost Performance Report (CPR). The paper addresses the development and use of contract performance data in OSD.

An overview of the financial aspects of the military Standard Contract Administration Procedures (MILSCAP) and the segments that the Air Force Systems Command's (AFSC) Acquisition Management Information System (AMIS) has working are presented in a comprehensive paper (84). AMIS is an automated system which contains over 500 computer programs, produces over 230 formatted outputs and includes a query capability for use by all management levels. Data is maintained for over 47,000 contracts containing more than 600,000 line items having obligations of approximately $100 billion. The author concludes that there is a great need for the military services and DCAS to develop and implement an automated capability to exchange contracting and financial data to increase standardization, accuracy and timeliness of forms preparation and to reduce abstracting workload.

Concepts and approaches to project cost and schedule integration and management within the Department of Energy is described in a paper (85) in which DOE's implementation of the Cost and Schedule Control System Criteria

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(82) Mallory, Melvin A.; Duvall, Russel W..
(83) Christle, Gary E..
(84) Mills, Kenneth E.; Ryan, Colonel Arthur R., USAF.
(85) Tromley, Thomas P..

is described in detail. The Department of Energy uses a system which parallel that of the Department of Defense. They are presently developing detailed guidance documentation. Five CSCSC guides are planned; two are available from the author at (202) 252-4057.

A working C/SCS for Naval shipbuilding is described in a paper authored by a Group Vice President of a major contractor (86). The paper relates how the company reaction to the Government's C/SCSC requirement was initially mixed. It then goes on to describe the system they installed and shows how they compare with the objectives set down over five years ago. The author concludes that they have designed a system appropriate to the peculiarities of Naval shipbuilding, which fully meets DODI 7000.2 criteria and works.

The use of spares optimization models in initial provisioning is recommended in a research paper which supports that view (87). The author contends that the DOD Standard Initial Provisioning (SIP) policy takes an item-oriented view based on a demand-based stockage and that any provisioning technique which does not take item cost explicitly into account will not be as cost effective as one that does. He contends that the SIP policy inhibits the intelligent conservatism in initial provisioning investment it seeks to achieve. Four fundamentally important conclusions are drawn from the analysis in the research paper. They are:

-- Spares optimization models provide a way to achieve specified levels of availability at substantially less cost than item-oriented policies; thus, they provide the policy maker with the opportunity to be conservative in spares investment while still providing effective weapon-system support.

-- Cost-effective stockage policies cannot be based on demand rates alone; all item characteristics must be considered.

-- The policy maker must view the depot and bases as an integrated system. One should not make policy for the "wholesale" level independent of the "retail" level.

-- Spares optimization models are more robust in the face of uncertainty than item-oriented policies.

The results of a reassessment of the status of Life Cycle Costing by the National Security Industrial Association (NSIA) Life Cycle Cost Ad Hoc Committee are reported in a paper authored by an industry executive (88). At the request of DOD, NSIA's committee had reviewed the status in the 70's and made thirty-eight recommendations in 7 major policy areas. This re-assessment produced 8 recommendations and concluded that the methodology is accepted in Government and industry. It was further concluded that, although

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(86) Whipple, G. Graham.
(87) Abell, John B..
(88) Earles, Donald R..

there is still a lack of data and totally integrated programs, life cycle cost methodology is improving, life cycle cost consciousness is growing, and life cycle cost control and minimization is starting to happen. The committee's recommendations to DOD are detailed in the paper. The NSIA has devoted several "mini" seminars to the subject. Most of the activity to date has been in the areas of Contractor Support, Warranties, and Guarantees.

A research paper which uses the premise that little has been done to diagnose the causes of cost growth identifies one possible driver of cost growth as the growth of contract requirements on research and development contracts (89). The research focuses on a methodology used to define, quantify and measure contract technical requirements for avionics research and development programs. From the foundation laid by this research, the author propose recommendations that can and should be implemented by management now and further recommends research avenues necessary to build on the foundation and lead to future management improvements.

Another research paper proposes a concept of "Mission Management" as a means of precluding cost, schedule and performance problems (90). The main directions for change cited include the statutory requirement to utilize mission area budgeting: to present mission deficiencies and proposed responses in a coherent and understandable format for the use of agency heads, budget examiners and Congressional review.

26. Effective Team Interfaces.

A research paper which summarizes a series of research projects that addressed an identified problem traces the actions and time frame from identification of a research need to results implementation (91). The paper reflects the author's experience as participants in a series of research projects to develop a capability to measure the effect of production rate changes on weapon system cost. The paper describes the series of projects, overall results and lessons learned and implications to acquisition managers and researchers about major issues important to acquisition research. Of the "lessons learned" an important message to management is that effective results take time. In the case used in this study, the development and testing of the procedure has taken six years from need identification to its present status of initial implementation. In the opinion of the authors, acquisition managers often need or want instant results and benefits, however, these results are often only temporary fixes to problems that will occur again and again and quite often become costly mistakes. An important lesson to the researchers for successful research results implementation is careful planning on the part of researchers. One seldom achieves the ill-defined goal. The general implication is that the success in this case is based on effective interface between acquisition managers, researchers and data sources. Finally, this research concludes that the continuity of research should be a key planning element. The linking of the research tasks toward an overall end contributes to research success.

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(89) Blackledge, Major Ronald G. USAF; Lockwood, Major Lyle W., USAF.
(90) Judson, Robert R..
(91) Smith, Larry L.; Glover, William L..

Transfer of Army contract technology as a means of improving the interface between acquisition managers, operators and researchers is proposed in another research paper (92). The author proposes that this might be accomplished by selective solicitation of ideas from those organizations which seem to do certain tasks well and, selective distribution of the ideas to organizations that might benefit. The paper emphasizes the potential for the sharing that might occur on a voluntary basis, rather than by mandate, providing some facilitating medium could be employed. A selectively utilized digest of contract management ideas is recommended.

A report on a preliminary test of a methodology for monitoring and evaluating the outputs in several fields/programs of a large Federal research laboratory is the basis for another research paper (93). Six pilot areas representing major units, programs, and fields were selected. Based on interviews with key individuals and examination of relevant documentation, several score of potential output indicators were identified. These were fed into a stage model of the R&D/Innovation process for each selected field/program. The model also included identified barriers, facilitators and transfer mechanisms for the transition of outputs between stages. The steps in developing and introducing a monitoring/evaluation system are described, as well as ways of integrating such a system into the routine management activities of the laboratory, including current reporting and programming procedures.

An innovative approach to including representatives of industry on a Solicitation Review Panel is described and evaluated in another paper (94). The paper describes various approaches taken by AFSC's Armament Division to improve the Request for Proposal (RFP) process: the Government Murder Board, the Business Strategy Panel, and the Draft Request for Proposal. Under the new technique, termed the Industry Murder Board, the Draft Request for Proposal is sent to industry for review and evaluation. Following this, selected Government and industry representatives meet in open forum to discuss and make oral comments and recommendations for improvement of the final RFP package. The technique is also being tested by some other product divisions of AFSC.

A comprehensive research paper by a Government professor of acquisition and program management (95) treats the interface between the DOD Manager, the OSD Policy-maker, and the Acquisition Researcher. The author describes the environment with which the acquisition policy-maker, manager and researcher are faced as a myriad of challenges and opportunities and describes the team effort required to resolve issues and accomplish DOD's main acquisition objective of fielding and supporting mature, cost-effective weapon systems to the operating forces. The paper reviews recent acquisition research studies which have had a significant impact on the acquisition process. The management of acquisition research is detailed. DOD Directive 4105.68 prescribes the

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(92) Griffiths, Kenneth D..
(93) Rubenstein, Albert H.; Geisler, Eliezer.
(94) Jennings, Anthony; McIntosh, Katherine; Williams, Anthony.
(95) Fargher, John S. W., Jr..

policies and procedures to initiate, conduct and coordinate acquisition research. An Acquisition Research Council (ARC) and Acquisition Research Coordinating Council (ARCC) have been established to provide research guidance and coordination. The councils are composed of senior acquisition policy members from OSD, the Services and DLA. Each Service has an acquisition research element responsible for programming, budgeting, funding and other related support for their research efforts. A Memorandum of Understanding (MOU) has been signed by the heads of the respective acquisition research elements to document the cooperative efforts among the elements. The Defense Acquisition Research Element (DARE) Working Group elements are: the Research Division of the Defense Systems Management College; the Army Procurement Research Office (AFRO) at Ft. Lee, VA; the Office of Naval Research/Navy Center for Acquisition Research, Arlington, VA; and the Air Force Business Research Management Center (AFBRMC), Wright-Patterson AFB, OH, with the Federal Acquisition Institute (FAI) as an ad hoc participant. The DARE Working Group functions to coordinate acquisition research programs, exchange program information, exchange technical expertise by review and evaluations of proposals, assist in developing joint programs, and disseminating relevant research results within their respective Service and OSD staffs. The DARE Working Group provides assistance and support of this Annual DOD/FAI Acquisition Research Symposium to exchange results among OSD policy-makers, DOD Acquisition managers, acquisition researchers and industry. Projects with interest to more than one element are considered for cooperative, joint programs in the form of joint funding, follow-on funding by another element to broaden applicability, joint data bases for the lead DARE, and joint service testing of acquisition innovations. The research paper presents a model for management of acquisition research and a multi-disciplinary approach to problem solving. It also makes a point for better use of industry acquisition research capabilities.

A research paper by two Government research professionals approaches the relationship of the manager, the policy-maker and the researcher as a team for effective problem solving (96) on the premise that research based responses to changing conditions tend to be more effective and lasting than ad hoc reactions. It makes the point that, to be applied effectively, acquisition research requires teamwork between managers, policy-makers, and researchers. Ways and examples of how to obtain this teamwork are presented. Research implementation techniques are highlighted. The paper concludes that problems in today's organizations should be solved systematically and the proper team must be selected. The choice of whether to use research or some less vigorous approaches should be made on a rational basis. The problem of implementing research is the job of the researcher and the policy-maker as well as the manager and must be of as much concern as the quality of the research itself.

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(96) Arvis, Paul F., Williams, Robert F..

G. HUMAN RESOURCES MANAGEMENT

27. Acquisition Work Force.

The Federal Acquisition Institute (FAI) has pioneered a new approach to the management of personnel programs in the Federal Government. In 1978, an occupational survey of the GS-1102 and 1105 series was administered to some 20,000 Federal civilian and military employees. The results of that survey were analyzed using an established occupational analysis methodology. The results of that analysis are summarized in a research paper (97). The analysis identified six major functional areas. Within each of these areas, 54 job types were identified. In two areas, job types were identified. In two areas, Contract Generalist and Staff, job types were organized by families of related jobs within the area. The analysis points out the implications of this type of information for personnel management and how it can support functional managers for the best utilization of their employee resources. The information will be of greater use in the future. The data is a base-line. When occupations are surveyed again, they will be able to identify trends, measure impact of procurement and personnel policy changes, and anticipate changes that are in the process of evolving. If problem areas have been identified, the extent to which they have been cured will be visible as well as if new problems have arisen. The information included in the data base will permit FAI to forecast needs in terms of personnel replacement, recruiting and selection.

A research paper on training (98) presents a review of some of the source literature undergirding four trends of the direction of training to meet the increasing, yet differentiated, training of the 1980's. The four trends are: (1) the shifting from the knowledge and skill transmission model toward a competency development model; (2) the growing body of knowledge regarding needs, styles and processes of adult learning; (3) the requirement to provide a more diversified and flexible delivery system for training; and (4) a larger component of the role of the managers being concerned with development of their subordinates. The paper concludes with the challenge of calling for specific actions to exploit the benefits of these four trends.

A research paper on the role of the U. S. Government's Contracting Officer (99) proposes solutions to the recommendations of the Commission on Government Procurement on organizational placement of procurement in agency organizations (recommendation A-12) and the role of the Contracting Officer (recommendations A-13 and A-14). Some of the highlights from "Federal Contracting and Procurement Workforce Demographics" published by the Federal Acquisition Institute (FAI) in September 1979, are included in the research paper. Some conclusions are drawn. Information on organizational placement of the procurement function from a survey by FAI is presented for the first time in this research paper. Seventeen agencies were surveyed with almost 500 procurement offices responding. In 13 agencies the most senior

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(97) Eustis, James N.
(98) Hood, Joseph L., Ph.D..
(99) Conrad, Davis M..

procurement person was two or more levels below the head of the agency. Another line of inquiry related to the Contracting Officer. In all the civil agencies, many positions, even those filled by non-procurement persons, give authority to the incumbent as Contracting Officer. Many agencies are currently preparing qualification and/or warranting procedures. FAI is coordinating this effort in order to allow interchangeability and some measure of uniformity. Other specific activities of FAI are detailed in the research paper. FAI has an on-going project which includes a coordination working group with the final aim of harmonizing the regulatory efforts.

One of the civil agencies has established a program of awarding certificates to procurement personnel who complete specific education and/or training courses, have specified experience, and meet other requirements. This first-of-its-kind program is described in a research paper (100). The certificate system provide goals for employees and management as to what courses to take and when, and recognizes employee achievement. Although the system is achieving its objective of developing professional procurement personnel, it is being restudied to make sure course material is pertinent, that standards are realistic, and that the administrative aspects are appropriate.

A research paper by a professional from the Office of Personnel Management (OPM) forecasts the eventual removal of procurement positions from the Professional and Administrative Career Examination (PACE) program (101). In lieu of the PACE program, the OPM plans to delegate its authority for examinations for ex-PACE occupations to the agencies. The agencies will not have PACE to staff the positions and they may not be allowed any written test for that purpose. The paper discusses the various staffing instruments that will be available to agencies and the various ways they can be combined to form examinations. The paper also describes OPM's standards for examinations and the process for designing examinations explicit in those standards.

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(100) Weinstein, Murray N.; Bailets, Lynn W..
(101) Miller, Michael Floyd.

H. ASSISTANCE AND COOPERATIVE AGREEMENTS

28. Grants vs Contracts.

The Federal Grant and Cooperative Agreement Act of 1977, Public Law 95-224, February 3, 1978, contains statutory provisions for the first time as to the kinds of effort that will be covered by contracts, grants or cooperative agreements. Prior to the passage of that Act legal instruments took varied forms. One research paper analyzes the impact of Public Law 93-352 on biomedical research contracts (102). That statute made biomedical research contracts subject to Scientific Peer Review. This necessitated changes in the method of project selection and review. As respects grants, however, the method of review was not altered appreciably as NIH had already had a system of Scientific Peer Review conforming to the statutory standards. Another statute, the Federal Advisory Committee Act, has also caused revisions in review procedures. This research paper discusses some interesting problems created by Public Law 93-352.

The ten year history of a Department of Education supported program, Reading is Fundamental (RIF), is traced in an interesting research paper (103). The program was originally supported under Right to Read legislation with funds provided to the Commissioner of Edcuation for use at his discretion under the now-repealed Cooperative Research Act. These monies augmented funds from State and local sources. Subsequent legislation which authorized the Inexpensive Book Distribution Program (IBDP) authorized the Commissioner of Education to contract with non-profit groups or public organizations whose primary purpose "is to motivate children to read". This paper describes how Reading is Fundamental, a non-profit organization, guided by such notables as Mrs. Robert McNamara, wife of the President of the World Bank and Mrs. Walter Mondale, wife of the Vice President of the United States, was awarded a fully justified non-competitive contract in 1976. Qualified State and local, private or public agencies can apply to function as subcontractors. The program has proven itself as a highly successful method of solving a national socio-economic problem. Its projects involve more than 3 million children at 13,000 sites in 11,000 schools and all 50 States.

The Department of Energy has developed innovative procedures to solicit proposals for research and development activities leading to the award of contracts, cooperative agreements or grants. One of these mechanisms called Program Research and Announcement (PRDAs) has proven to be a valuable tool in soliciting proposals from individuals, private entities and public entities (excluding Federal Agencies). A research paper (104) traces the statutory history and provisions for the use of these innovative competitive solicitations for contracts and cooperative agreements. PRDA's are a mechanism to provide potential proposers with information concerning DOE's interest in entering into arrangements for research, development and related projects in specified areas

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(102) Nolan, Arthur J..
(103) Seagears, M. Thomas; Webb, David A..
(104) Newman, David G..

of interest and to solicit solutions in the proposers own technical and business terms. Some projects may be assistance oriented involving proposer's projects needing only DOE financial assistance. Multiple grants, cooperative agreements or acquisition contracts may result from a given PRDA. No other department or agency is using a single type instrument to invite multiple type responses to needs.

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(19) Fredericksen, Donald N.; Kornhauser, Bernard, "Tracked Vehicle Resource Analysis and Display (Tread) Cost Model", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 4-37.

(20) Corderman, Douglas G., "Lessons to be Learned by DOD Acquisition Managers From the Commercial Procurement World", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 3-3.

(21) Hill, Richard M., "Raising Government Purchasing Efficiency Through Industrial Purchasing Techniques", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 3-9.

(22) Galper, Morton, "The Role of Marketing Communications in Organizational Buying: Implications and Opportunities for Federal Procurement Practice", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 3-23.

(23) Schill, Dr. Ronald L., "Conceptualizing the Acquisition Process of Organizations: Approaches and Strategies", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 3-39.

(24) Williams, Robert F., "Significant Similarities and Differences Between Federal and Other Organizational Buying", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 3-33.

(25) Ostrowski, George S.; Lockwood, Major Lyle W., USAF, "Simplifying Contracts for Commercial Systems", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 3-15.

(26) Sherman, Stanley N., "Fitting the Contract to the Acquisition", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 10-31.

(27) DeMong, Richard F., D.B.A.; Strayer, Daniel E., Ph.D., "Incentive Contracting: The Underlying Theory", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 10-3.

(28) Hunt, Raymond G., "Award Fee Contracting Applications in the U. S. Air Force Systems Command", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 10-27.

(29) Thompson, Charles W. N.; Rubenstein, Albert H., "The Leader/Follower Concept in Acquisition", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 10-39.

(30) Meiners, Dr. Arthur C., Jr., "Use of Fixed Price Incentive/Awards Fee Contracts for the Construction of Follow U.S. Navy Ships", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 10-21.

(31) Parry, LCDR D. S., SC, USN; Sellers, LCDR B. R., SC, USN, "Second Sourcing in Major System Acquisitions", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 10-11.

(32) Guy, M. Kathy; Overall, Colonel Douglas, USAF, "Major Steps in a Cost Comparison Study/Contracting-Out for Supply Services at Patrick Air Force Base, Florida", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 7-19.

(33) Briggs, R. L., "Socio-Economic Implications of the Defense Budget and Multiple-Year Procurements", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 7-13.

(34) Cavanagh, James; Tychan, Terrence, "Effective Acquisition Through the Elimination of Wasteful Year-End Spending-HEW, A Case Study", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 7-29.

(35) Jacobs, Grady L., "DOD Profit Policy for the 1980's", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 9-31.

(36) Nick, Robert W., "Effectiveness of Profit Negotiations in the Promotion of Contractor Efficiency", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 9-3.

(37) Herington, David L.; Kalal, Gerald W., "Economic Price Adjustment Provisions in Government Contracting and Suggested Alternatives", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 9-19.

(38) Hammon, Captain Colin; Graham, Dr. David R., "Estimation and Analysis of Navy Shipbuilding Program Disruption Costs", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 9-7.

(39) Unruh, Daniel D., "Enhancement of Competition in the Department of Defense", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 15-41.

(40) Martin, Colonel Martin D.; Golden, Major Robert F., "Competition in Department of Defense Acquisition", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, 15-11.

(41) Smith, Charles H., "Evaluation of Competitive Alternatives for Weapon System Production", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 15-3.

(42) Brannan, Richard C., "Forecasting Savings from Repetitive Competition with Multiple Awards", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 15-7.

(43) Solinsky, Kenneth S., "A Procurement Strategy for Achieving Effective Competition While Preserving an Industrial Mobilization Base", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 15-21.

(44) Drinnon, J. W.; Gansler, J. S., "Predicting the Costs and Benefits of Competitive Production Sources", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 15-31.

(45) Fargher, John S. W., Jr., "An Analysis of Joint Service Acquisition Programs", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 1-3.

(46) Atkinson, A. S., "Source Acquisition Strategy Implications Drawn from a Theoretical Examination of the Front End of the Process", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 1-41.

(47) DeWispelare, Aaron; Sage, Andrew P.; White, Chelsea C., III, "A Multicriterion Planning Aid for Defense Systems Acquisition With Application to Electronic Warfare Retrofit", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 1-15.

(48) Roesch, Maurice; Sage, Andrew P., "Systems Engineering Methodology for Defense Systems Acquisition", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 1-23.

(49) Jacoby, Major James E., USAF, "The Program Planning and Management System and Its Use in the Management of a Space Program", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 1-49.

(50) Moeller, William G., "Accelerating the Decision Process in Major System Acquisitions", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 1-9.

(51) Huber, Major Robert A, USAF; Vitelli, Captain James, USAF, "A New Concept for Managing the Contract Award Process", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 8-27.

(52) Spector, Dr. Bertram I.; Hayes, John J., Major General USA (Ret), "Productivity Improvement Through Incentive Management", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 8-3.

(53) Daschbach, James M., Ph.D.; Henry, Eugene W., Ph.D., "Work Simplification Technology As An Acquisition Parameter", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 8-7.

(54) Nebeker, Delbert M.; Shumate, E. Chandler, "Productivity Improvement: A Program for Small Purchase Buyers and Supply Clerks", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 8-21.

(55) Robinson, Rodney A., "Production Oriented Planning", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 8-33.

(56) Massey, Dr. Robert J.; Smith, Gordon A.; Witten, Jack T., "Improving the Acquisition System", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 8-11.

(57) Bemis, John C., "Production Rate as an Affordability Issue", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 1-35.

(58) Wolniewicz, Lt Col. Peter F., USAF, "Improved Acquisition of Munitions - Two Years Later", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 18-3.

(59) Brennan, James R., "Production Readiness - The First Year in Review", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 18-7.

(60) Boyd, Major George V., III; Anderson, Joseph B., "Manufacturing Technology Investment Strategy", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 18-13.

(61) Holt, Jack A., "Production Decision Framework: A Dynamic Planning Model", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 18-17.

(62) Collins, John T., "Concept and Assessment of the Validated Drawing Program in the FFG-7 Class Ship Acquisition", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 18-27.

(63) Martin, Colonel Martin D.; Lockwood, Major Lyle W., "Managerial Analysis System for Manufacturing and Quality Assurance (MASMAQA)", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 6-3.

(64) Epstein, Ira J., "Quality Horizons Study", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 6-33.

(65) Orphanos, John A., "Productivity Assurance in Systems Acquisition", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 8-41.

(66) Theede, Edward, "Quality Incentives and the Government's Role in Procurement Quality Assurance with the Rapidly Changing Technology", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 6-29.

(67) Crum, Fred B; Fiorentino, Eugene, "The Use of Warranty-Guarantee in the Acquisition of Ground Electronic Equipment", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 6-11.

(68) Blischke, Wallace R.; Scheuer, Ernest M., "Models for Analysis of Warranty Policies", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 6-21.

(69) Chalecki, Ronald R., "KC-10 Warranty and Service Life Policy", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 6-43.

(70) Davis, George R., "A Technique for Improving the Effectiveness of the Logistics Support Analysis Process", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 11-11.

(71) Swanson, Donald K.; Gastineau, Charles E., "Avoiding the Costly Pitfalls of Engineering Documentation for High Reliability Parts Used in Military Systems", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 11-21.

(72) Henscheid, Lt Col. Robert; Long, Captain Floyd D., Jr.; Martisaukas, Captain Algio J., "Affordable Automatic Testing - A Modular Concept", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 11-31.

(73) Gross, Major Paul W., Jr.; Stock, Dr. James R., "Transportation Costs as a Consideration in Air Force Contracts", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 11-37.

(74) Demmy, W. Steven; Cicciano, Gloria J., "Inventory Management Research: Some Recent Findings and New Directions for the 1980's", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 11-47.

(75) Morris, Kenneth L., "Air Force Application of Logistics Support Analysis", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 11-53.

(76) Cooper, Captain Virgil L., "An Investigation of the Software Requirements Allocation Process in the Acquisition and Management of a Major Defense System", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 11-3.

(77) Voss, John D. Lt Col., USAF, "Lamis - A Working, Effective Procurement Management Information System", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 12-11.

(78) Schmidt, Frank L., "Totally Integrated Management Evaluation System", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 12-17.

(79) Rogers, William J,; Begley, Clyde, "Increasing Productivity in Procurement Through the Use of Automation", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 12-23.

(80) Greenberg, Stephen J., Ph.D., "Reporting Federal Procurement Acitivty: A Review of the Federal Procurement Data System", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 12-27.

(81) Meigs, Daniel K., "Information System Requirements of the Acquisition Community", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 12-33.

(82) Mallory, Melvin A.; Duvall, Russel W., "Fourier Analysis - A Modern Technique - A Breakthrough to Higher Productivity", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 12-3.

(83) Christle, Gary E., "Automation of Program/Project Cost Reports Within DOD", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 14-3.

(84) Mills, Kenneth E.; Ryan, Colonel Arthur R., USAF, "AFSC's Acquisition Management Information System With Emphasis on MILSCAP Financial Aspects", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 14-9.

(85) Tromley, Thomas P., "Concepts and Approaches to Project Cost and Schedule Integration and Management Within DOE", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 14-15.

(86) Whipple, G. Graham, "A Working C/SCS for Naval Shipbuilding", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 14-21.

(87) Abell, John B., "The Use of Spares Optimization Models in Initial Provisioning", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 14-29.

(88) Earles, Donald R., "Life Cycle Cost Revisited", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 14-37.

(89) Blackledge, Major Ronald G., USAF; Lockwood, Major Lyle W., USAF, "Measurement of Avionics Contract Research and Development Requirements and Their Growth", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 5-3.

(90) Judson, Robert R., "A Navy Model for Decision-Making in Acquiring Major Systems", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 5-27.

(91) Smith, Larry L.; Glover, William L., "From Research Need Identification to Results Implementation", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 17-3.

(92) Griffiths, Kenneth D., "Transfer of Army Contract Management Technology", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 17-9.

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(94) Jennings, Anthony; McIntosh, Katherine; Williams, Anthony, "Functional Value of the Industry Murder Board", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 17-19.

(95) Fargher, John S. W., Jr., "The Interface Between the DOD Manager, The OSD Policy-Maker and the Acquisition Researcher- A Study of Management by Compulsion", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 17-21.

(96) Arvis, Paul F.; Williams, Robert F., "The Manager, the Policy Maker, and the Researcher: A Team for Effective Problem Solving", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 17-31.

(97) Eustis, James N., "An Analysis of Work Performance of the Contracting and Procurement and Purchasing Specialities", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 16-3.

(98) Hood, Joseph L., Ph.D., "Training in the 1980's", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 16-7.

(99) Conrad, David M., "A Solution for COGP Recommendations A-12, 13, and 14, Regarding the Contracting Officer", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 16-15.

(100) Weinstein, Murray N.; Bailets, Lynn W., "HEW Certification Program", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 16-21.

(101) Miller, Michael Floyd, "The Impending Demise of PACE; Ramifications for Staffing Procurement Positions", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 16-25.

(102) Nolan, Arthur J., "The Imapct of P.L. 93-352 on Biomedical Research Contracts", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 2-3.

(103) Seagears, M. Thomas; Webb, David A., "A Pipedream Grant that Became a Productive Contract", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 2-5.

(104) Newman, David G., "Innovative Competitive Solicitations for Contracts and Cooperative Agreements", Ninth Annual DOD/FAI Acquisition Research Symposium, June 1980, p. 2-11.

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NINTH ANNUAL
DOD/FAI
ACQUISITION RESEARCH
SYMPOSIUM

"ACQUISITION OF AFFORDABLE SYSTEMS IN THE 1980's"

Co-Sponsored by:
DEPARTMENT OF DEFENSE
FEDERAL ACQUISITION INSTITUTE

Host:
DEPARTMENT OF THE NAVY

Held at:
UNITED STATES NAVAL ACADEMY
ANNAPOLIS, MARYLAND
JUNE 9–11, 1980

PROGRAM

NINTH ANNUAL DOD/FAI

ACQUISITION RESEARCH SYMPOSIUM

JUNE 9 - JUNE 11, 1980

UNITED STATES NAVAL ACADEMY

ANNAPOLIS, MARYLAND

"ACQUISITION OF AFFORDABLE SYSTEMS IN THE 1980'S"

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DEPARTMENT OF DEFENSE

FEDERAL ACQUISITION INSTITUTE

HOST:

DEPARTMENT OF THE NAVY

OFPP Priorities
PL 95-507

Church – • Stability
• Multi-year contracts
challenge to symposium → • Realistic Estimates (Truth in \$)

PROGRAM

NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM

THEME: "Acquisition of Affordable Systems in the 1980's"

MONDAY - 9 JUNE 1980

White: emphasize • Aim @ big pblms
• Avoid "sloganeering"
• data & careful analysis, persuasive arguments
• pay attn. to institutions
• listen to real problems of audience

0730 - 0845 - **BUS DEPARTURE** - Motels to Naval Academy

0730 - 0900 - **REGISTRATION** - Rickover Hall, Lobby

0800 - 0900 - **COFFEE** - Mahan Hall

0900 - 0930 - **OPENING, WELCOMING REMARKS** - Mahan Hall
Dr. Thomas C. Varley
Symposium Chairman
Rear Admiral William P. Lawrence, USN
Superintendent, United States Naval Academy
Mr. Dale W. Church
Deputy Under Secretary of Defense (Acquisition Policy)

0930 - 0935 - **INTRODUCTION OF KEYNOTE SPEAKER**
Honorable Karen Hastie Williams
Administrator, Office of Federal Procurement Policy, OMB

0935 - 1015 - **KEYNOTE ADDRESS**
Dr. John P. White, Deputy Director, Office of Management and Budget, Executive Office of the President

1015 - 1030 - **COFFEE BREAK**

1030 - 1200 - **PRESENTATION** - "Acquisition Lessons Learned in the 70's"
Mr. Robert Perry
Rand Corporation

1200 - 1330 - **LUNCHEON** - Officers' and Faculty Club

1330 - 1500 - **CONCURRENT SESSIONS** - Rickover and Michelson Halls
Program Management - Rickover, Room 102
B/G William E. Thurman, USAF, Session Manager
1500 - 1530 (Break)
Assistance and Cooperative Agreements - Michelson, Room 117
Mr. Thomas L. Hadd, Session Manager
1530 - 1700 (Continue Session)
Federal Buying and Organizational Buying - Michelson, Room 103
Professor Jagdish N. Sheth, Session Manager
Cost Estimating - Rickover, Room 103
Colonel Richard C. Goven, USAF, Session Manager

1730 - 1830 - **SOCIAL HOUR (No-host)** - Hubbard Hall, Boat House

1900 - 1930 - **BUS DEPARTURE** - Hubbard Hall to Motels

TUESDAY - 10 JUNE 1980

0700 - 0745 - **BUS DEPARTURE** - Motels to Naval Academy

0730 - 0830 - **COFFEE** - Rickover and Michelson Halls

0830 - 1000 - **CONCURRENT SESSIONS** - Rickover and Michelson Halls
Front-End Affordability, Mission Needs, Mission Budgeting - Rickover Hall, Room 102
Mr. Fred H. Dietrich, Session Manager
Product Assurance - Michelson, Room 117
1000 - 1030 - (Break)
Lt. Colonel Richard S. Sapp, Session Manager
Contracting Environment - Rickover Hall, Room 103
1030 - 1200 - (Continue Session)
Mr. Thomas F. Williamson, Session Manager
Productivity - Rickover Hall, Room 110
Dr. J. W. Tweeddale, Session Manager
Pricing - Michelson Hall, Room 103
Dr. Janie L. Creech, Session Manager

1200 - 1330 - **LUNCHEON** - Officers' and Faculty Club

1330 - 1500 - **CONCURRENT SESSIONS** - Rickover and Michelson Halls
Contracting Methods - Rickover Hall, Room 102
Rear Admiral N. P. Ferraro, USN, Session Manager
1500 - 1530 - (Break)
Logistics/ILS - Michelson Hall, Room 117
Mr. Charles O. Coogan, Session Manager
1530 - 1700 - (Continue Session)
Procurement Automation and MIS - Rickover Hall, Room 103
Mr. Neil Lamb, Session Manager
International Collaboration - Rickover Hall, Room 110
Dr. Franz A. P. Frisch, Session Manager
Financial Management and Budgeting - Michelson Hall, Room 103
Captain C. H. Piersall, Jr., USN, Session Manager

1700 - 1830 - **BUS DEPARTURE** - Naval Academy to Motels and return to Hilton Inn

1830 - 1930 - **SOCIAL HOUR (No-host)** - Hilton Inn, Poolside Terrace

1930 - 2230 - **BANQUET** - Hilton Inn
Speaker: Honorable Joseph A. Doyle
Assistant Secretary of the Navy
(Manpower, Reserve Affairs and Logistics)

2230 - 2300 - **BUS DEPARTURE** - Hilton Inn to Motels

WEDNESDAY - 11 JUNE 1980

0700 - 0745 - **BUS DEPARTURE** - Motel to Naval Academy

0730 - 0800 - **COFFEE** - Rickover and Michelson Halls

0800 - 1100 - **CONCURRENT SESSIONS** - Rickover and Michelson Halls
Competition - Rickover Hall, Room 102
Mr. Thomas E. Harvey, Session Manager
Procurement People, Professionalism and Organization - Michelson Hall, Room 117
Mr. William N. Hunter, Session Manager
Effective Team Interfaces - Rickover Hall, Room 103
Mr. John N. Jury, Session Manager
Production Planning and Manufacturing Technology, Michelson Hall, Room 103
Mr. James J. Mattice, Session Manager

1115 - 1200 - **PLENARY SESSION** - Mahan Hall
Closing Remarks: Mr. Robert F. Trimble, Director, Contracts and Systems Acquisition (OUSDRE)
Mr. William N. Hunter, Director, Federal Acquisition Institute

1200 - 1230 - **BUS DEPARTURE** - Mahan Hall to Motels

CONCURRENT SESSIONS

Session #1

PROGRAM MANAGEMENT

Rickover Hall - Room 102

Monday - 9 June 1980 (1330-1700)

Panel Members: Brigadier General William E. Thurman, USAF, Session Manager; Vice Admiral E. R. Seymour, USN; Major General Forrest S. McCartney, USAF; Colonel Ivar W. Rundgren, USA.

An Analysis of Joint Service Acquisition Programs
Professor John S. W. Fargher, Jr.

Accelerating the Decision Process in Major System Acquisition
Mr. William G. Moeller

A Multicriterion Planning Aid for Defense Systems Acquisition with Application to Electronic Warfare Retrofit
Mr. Aaron DeWispelare
Dr. Andrew P. Sage
Mr. Chelsea C. White, III

Systems Engineering Methodology for Defense Systems Acquisition
Dr. Maurice Roesch
Dr. Andrew P. Sage

Production Rate as an Affordability Issue
Mr. John C. Bemis

Some Acquisition Strategy Implications Drawn from a Theoretical Examination of the Front End of the Process
Mr. A. Stuart Atkinson

The Program Planning and Management System and Its Use in the Management of a Space Program
Major James E. Jacoby, USAF

Session #2

ASSISTANCE AND COOPERATIVE AGREEMENTS

Michelson Hall - Room 117

Monday - 9 June 1980 (1330-1700)

Panel Members: Mr. Thomas L. Hadd, Session Manager; Mr. Charles F. Bingman; Mr. Robert E. Little, Jr.; Mr. William F. Raub; Mr. Robert L. Van Ness.

The Impact of P.L. 93-352 in Biomedical Research Contracts
Mr. Arthur J. Nolan

A Pipedream Grant That Became a Productive Contract
Mr. M. Thomas Seagears
Mr. David A. Webb

Cooperative Agreements: What Do We Mean By Substantial Involvement?
Mr. Charles Hulick

Innovative Competitive Solicitations for Contracts and Cooperative Agreements
Mr. David G. Newman

Overview of Assistance Reform Initiatives
Mr. Thomas L. Hadd

Session #3

FEDERAL BUYING AND ORGANIZATIONAL BUYING

Michelson Hall - Room 103

Monday - 9 June 1980 (1330-1700)

Panel Members: Professor Jagdish N. Sheth, Session Manager; Major General Jere W. Sharp, USA; Mr. Roland J. Baker; Mr. Charles M. Scott.

Lessons to be Learned by DOD Acquisition Managers from the Commercial Procurement World
Mr. Douglas G. Corderman

Raising Government Purchasing Efficiency Through Industrial Purchasing Techniques
Professor Richard M. Hill

Simplifying Contracts for Commercial Systems
Mr. George S. Ostrowski
Major Lyle W. Lockwood, USAF

The Role of Marketing Communications in Organizational Buying: Implications and Opportunities for Federal Procurement Practice
Dr. Morton Galper

Significant Similarities and Differences Between Federal and Other Organizational Buying
Mr. Robert F. Williams

Conceptualizing the Acquisition Process of Organizations: Approaches and Strategies
Dr. Ronald L. Schill

Impediments to Buying Commercially
Captain Steve Lathrop, USAF

Session #4

COST ESTIMATING

Rickover Hall - Room 103

Monday - 9 June 1980 (1330-1700)

Panel Members: Colonel Richard C. Goven, USAF, Session Manager; Mr. Marvin Elkin; Major Grady L. Jacobs, USAF; Mr. Robert Shue; Mr. Edward A. Swoboda.

An Engineer's View of Parametric Cost Estimation
Dr. James M. Daschbach

A Cost Function for Military Airframes
Mr. Norman K. Womer

A Generalized Approach to the Improvement Curve
Mr. E. B. Cochran

An Empirical Analysis of the Relationship Between Cost, Cost Estimation, and Cost Analysis
Colonel Martin D. Martin, USAF
Captain William L. Glover, USAF

Tracked Vehicle Resource Analysis and Display (Tread) Cost Model
Mr. Donald N. Fredericksen
Mr. Bernard Kornhauser

Cost Estimating Credibility: Specification and Requirement Satisfaction Criteria
Dr. C. David Weimer

Session #5

FRONT-END AFFORDABILITY, MISSION NEEDS, MISSION BUDGETING

Rickover Hall - Room 102

Tuesday - 10 June 1980 (0830-1200)

Panel Members: Mr. Fred H. Dietrich, Session Manager; Mr. John H. Richardson; Mr. Robert Steve Dotson; Mr. David J. Hessler.

Measurement of Avionics Contract Research and Development Requirement and Their Growth
Major Ronald G. Blackledge, USAF
Major Lyle W. Lockwood, USAF

Mission Analysis: A New Emphasis at the Product Division
Mr. Jerome P. Sutton

Affordability - Not a Dirty Word
RADM L. S. Kollmorgen, USN

The DOD Affordability Policy
Mr. Truxton R. Baldwin

A Navy Model for Decision-Making in Acquiring Major Systems
Mr. Robert P. Judson

An Approach to Quantifying the Need in Mission Element Need Statements
CDR Charles M. Garverick, USN
Mr. William L. Welch

Session #6

PRODUCT ASSURANCE

Michelson Hall - Room 117

Tuesday - 10 June 1980 (0830-1200)

Panel Members: Lt. Colonel Richard S. Sapp, USAF, Session Manager; Mr. Raphael Mur; Mr. Paul Davis; Colonel Ben H. Swett, USAF; Mr. Rolph Townshend.

Managerial Analysis Systems for Manufacturing and Quality Assurance (MASMAQA)
Colonel Martin D. Martin, USAF
Major Lyle W. Lockwood, USAF

The Use of Warranty-Guarantee in the Acquisition of Ground Electronic Equipment
Mr. Fred B. Crum
Mr. Eugene Fiorentino

Models for Analysis of Warranty Policies
Mr. Wallace R. Blischke
Mr. Ernest M. Scheurer

Quality Incentives and the Government's Role in Procurement Quality Assurance with the Rapidly Changing Technology
Mr. Edward Theede

Quality Horizons Study
Mr. Ira J. Epstein

Are Commercial Warranties Applicable to Military Aircraft Programs? A KC-10 Study
Mr. Ronald R. Chalecki

Session #7

CONTRACTING ENVIRONMENT

Rickover Hall - Room 103

Tuesday - 10 June 1980 (0830-1200)

Panel Members: Mr. Thomas F. Williamson, Esq., Session Manager; Mr. Gerald J. Mossinghoff, Esq.; Mr. Bruce Shirk, Esq.

Bakke, Weber and Affirmative Action in the 1980's
Ms. Jeanne M. Colachico

Socio-Economic Implications of the Defense Budget and Multiple-Year Procurements
Mr. R. L. Briggs

Major Steps in a Cost Comparison Study/Contracting Out for Supply Services at Patrick Air Force Base, Florida
Ms. M. Kathy Guy
Colonel Douglas Overall, USAF

P.L. 95-507 -- A New Focus
Mr. Justin P. Patterson
Mr. Alton Woods

Effective Acquisition Through the Elimination of Wasteful Year-end Spending
Mr. James J. Cavanagh
Mr. Terrence Tychan

Session #8

PRODUCTIVITY

Rickover Hall - Room 110

Tuesday - 10 June 1980 (0830-1200)

Panel Members: Dr. J. W. Tweeddale, Session Manager; Mr. Dale B. Hartman; Mr. Charles H. Kimsey.

Productivity Improvement Through Incentive Management
Dr. Bertram I. Spector
M/G John J. Hayes, USA (Ret.)

Work Simplification Technology As an Acquisition Parameter
Dr. James M. Daschbach
Dr. Eugene W. Henry

Improving the Acquisition System
Dr. Robert J. Massey
Mr. Gordon A. Smith
Mr. Jack F. Witten

Productivity Improvement: A Program for Small Purchase Buyers and Supply Clerks
Dr. Delbert M. Nebeker
Dr. E. Chandler Shumate

A New Concept for Managing the Contract Award Process
Major Robert A. Huber, USAF
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Mr. L. P. Clark
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FOREWORD

The Ninth Annual DOD/FAI Acquisition Research Symposium, jointly sponsored by the Department of Defense and the Federal Procurement Policy, OMB, will be held at the United States Naval Academy, Annapolis, Maryland, on June 9-11, 1980, with the Department of the Navy serving as the host.

The Symposium theme is "Acquisition of Affordable Systems in the 1980's." The purposes will be to present on-going and completed acquisition research related to specific areas of the acquisition cycle, and to provide a forum for open discussion of the issues involved among qualified individuals in government, industry and academia. Research paper authors will present summaries of their research in the following sessions:

- Program Management
- Assistance and Cooperative Agreements
- Federal Buying and Organizational Buying
- Cost Estimating
- Front-End Affordability, Mission Needs, Mission Budgeting
- Product Assurance
- Contracting Environment
- Productivity
- Pricing
- Contracting Methods
- Logistics/ILS
- Procurement Automation and MIS
- International Collaboration
- Financial Management and Budgeting
- Competition

* Procurement People, Professionalism and Organization

* Effective Team Interfaces

* Production Planning and Manufacturing Technology

In presenting their summaries, authors will highlight: What the problem was, why it was important, how the research focused on the methodology, where it occurs in the acquisition cycle, how it will be or is being implemented, and who is the user.

Since the research papers will not be read at the symposium by the authors, this volume is being mailed to attendees in advance of their departure from home or duty to attend the symposium. Additionally, the attendee can select which of the concurrent sessions to attend and be better prepared to participate.

Some of the research papers were not available at printing time. The titles and names of the authors of those papers are listed in the Table of Contents. An Addendum containing these other papers will be distributed with the symposium notebook at the time of registration.

The National Contract Management Association (NCMA) has agreed to review these research papers and present awards to the top four researchers.

Correspondence pertaining to these proceedings should be addressed to:

Ninth Annual DOD/FAI Acquisition Research Symposium
Suite 705, Crystal Mall One
1911 Jefferson Davis Highway
Arlingtin, VA 22202

NOTE

The views expressed in these proceedings are those of the authors and do not necessarily reflect the views of the organizations with which the authors are associated.

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NATIONAL CONTRACT MANAGEMENT ASSOCIATION (NCMA)

AWARDS

Continuing a practice established for previous DOD/FAI Acquisition Research Symposia, the National Contract Management Association (NCMA) organized a group of qualified members to review the research papers published in the Proceedings on the first of May. Papers published in the Addendum were not included due to time constraints. As a professional society NCMA is active in stimulating acquisition research and promoting the writing of research papers.

The quality of the papers was so high this year that five research papers were selected for awards of recognition. Certificates honoring the authors will be presented by Mr. William N. Hunter, Director of the Federal Acquisition Institute at the closing plenary session.

The selected papers and authors are:

1st Place - David L. Herington and Gerald W. Kalal, "Economic Price Adjustment Provisions in Government Contracting and Suggested Alternatives" (Page 9-19).

2nd Place (tie) - Dr. Edward M. Kaitz, "NATO RSI and National Industrial Structures" (Page 13-33).

- Dr. Joseph L. Hood, "Training in the 80's" (Page 16-7).

3rd Place - Jack A. Holt, "Production Decision Framework: A Dynamic Planning Model" (Page 18-17).

4th Place - E. B. Cochran, "A Generalized Approach to the Improvement Curve" (Page 4-15).

5th Place - Richard C. Brannon, "Forecasting Savings from Repetitive Competition with Multiple Awards" (Page 15-7).

Some of the criteria used in the judging by members of the NOVA Chapter are:

1. Overall contribution to the body of knowledge pertaining to the profession.

2. Depth of thought and original effort necessary to produce the paper.

3. Display of scholarship and application of research methodology.

4. Timeliness and thought provocation towards current and future challenges and problems.

5. A subjective opinion of the paper as to its relative merit as a part of these proceedings.

PROGRAM MANAGEMENT

SESSION MANAGER

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Commandant
Defense Systems Management College

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Air Force Systems Command

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Project Manager
Advanced Scout Helicopter

An Analysis of Joint Service Acquisition Programs

John S. W. Fargher, Jr.
Professor of Acquisition/Program Management
Defense Systems Management College

Abstract

The basis for this article is the *Guide for the Management of Joint Service Programs* prepared under the sponsorship of the Joint Logistics Commanders. This paper addresses the lessons learned uncovered by this research on joint service programs and how joint programs differ from single-service programs. Joint programs as here defined include only joint service involvement, not multinational programs.

Background

Few acquisition programs are joint from the concept formulation phase. They are preceded by individual service research and development efforts. Programs become joint for the following reasons:

—Avoidance of duplicative efforts and maximization of coordination of efforts in order to achieve a synergistic approach of combined service capabilities.

—Standardization/interoperability (S/I) of equipment, both between services and within NATO, resulting in a reduction in logistics requirements and improved support to the operating forces.

—Cost savings in the reduction of total development costs, consolidation of services production quantities for lower average unit price, and standardization for lower operation and support costs.

—Savings of other scarce resources such as U.S. Government and contractor personnel and facilities.

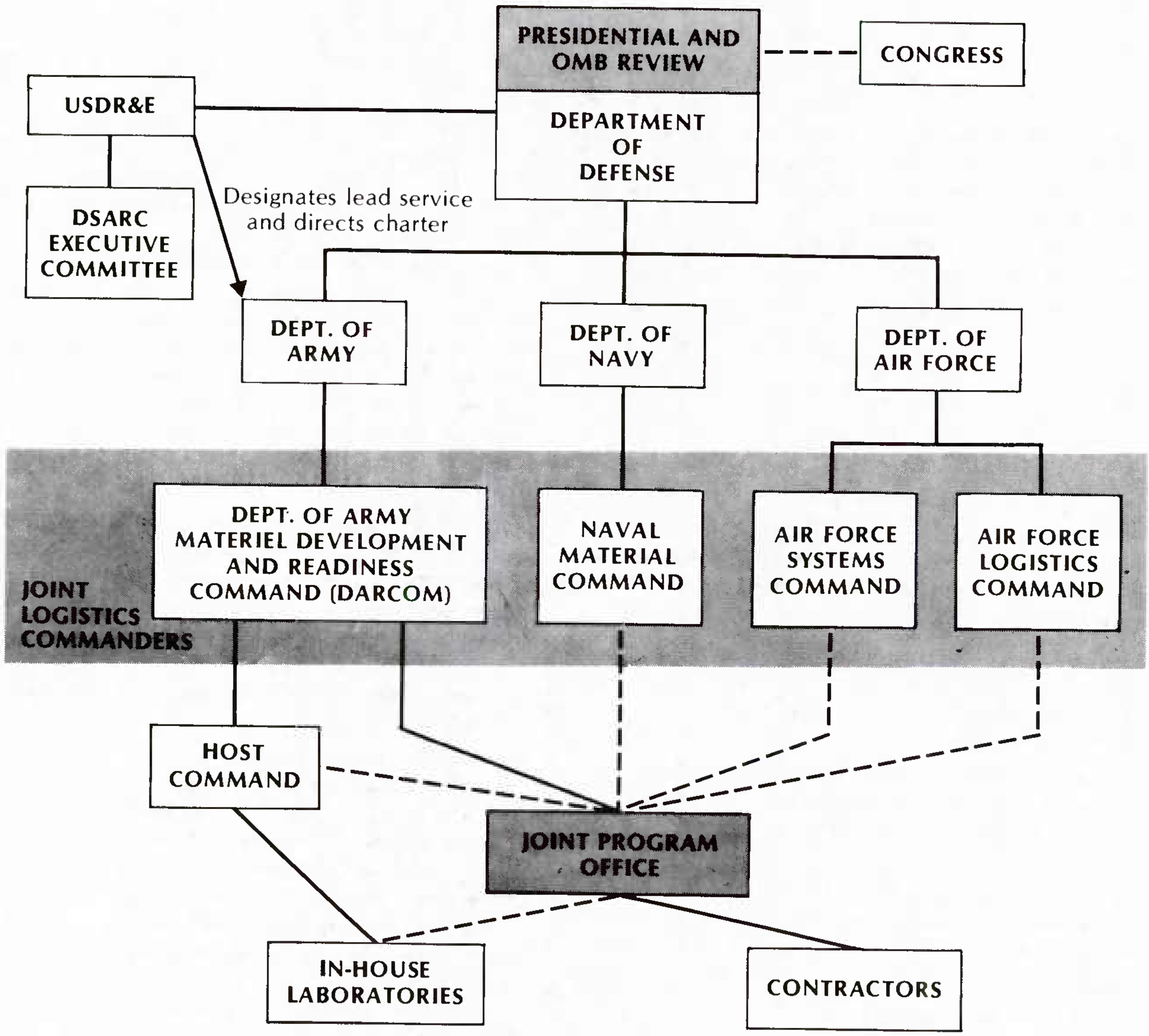
A joint program is usually initiated based upon direction from the Under Secretary of Defense for Research and Engineering (USDR&E) in the form of a memorandum designating a lead or executive service and directing that service to charter the joint program. DOD directives, however, have been issued for two programs, Mobile Electric Power and the Joint Tactical Communications (TRI-TAC) program. Direction is also given to the services on joint programs during the OSD and congressional budget reviews. OSD and Congress strongly support and encourage joint programs. Figure 1 gives an example of a joint program office hierarchy or organization.

The Joint Logistics Commanders (see Figure 1) signed a "Memorandum of Agreement on the Management of Multi-Service Systems/Programs/Projects" on July 20, 1973, subsequently issued as joint regulation AFLC/AFSC R. 800-2/AMCR 70-59/NAVMATINST 5000.1A. This memorandum establishes the policies for implementing joint programs. The service designated as the executive agent is to manage the program using their own policies and procedures. Only prior mutual agreements with the participating service will limit this authority. The memorandum goes on to delineate the responsibilities of the executive service and participating services in assignment of personnel, travel funds, and support; and documentation by a multi-service program manager charter, program master plan, joint operating procedures, and coordination/communication procedures to the participating services.

The standard integrated support management system (SISMS), implemented by DARCOM-R 700-97, NAVMATINST 4000.38, AFLC/AFSC 800-24, and MCO P4110.1A is a uniform approach to planning and managing the logistic support of multi-service programs. The Army has also directed that SISMS be applied to all Army weapon system programs. SISMS describes the policies, references, responsibilities, and data items, organized in the following chapters:

Chapter 1—Introduction and Concept
Chapter 2—Integrated Logistics Support Management
Chapter 3—Logistics Support Analysis Policy and Guidance
Chapter 4—Provisioning Policy and Procedures
Chapter 5—Support Equipment (SE)
Chapter 6—Government Furnished Equipment (GFE)
Chapter 7—Inventory Management Procedures
Chapter 8—Packaging/Handling/Storage/Transportability/Transportation
Chapter 9—Facilities Determination and Planning
Chapter 10— Preoperational Support
Chapter 11—Contractor Engineering and Technical Services (CETS)
Chapter 12—Interservice Depot Maintenance
Chapter 13—The Training Program
Chapter 14—Configuration Management
Chapter 15—Data Acquisition Management
Chapter 16—Technical Manuals Acquisition Management

Figure 1 **ORGANIZATIONAL HIERARCHY OF JOINT PROGRAM OFFICE**



Chapter 17—Engineering Drawings
Chapter 18—Data Exchange for Product Improvement
Chapter 19—Data Element Dictionary
Chapter 20—Budget and Funding
Chapter 21—Procurement
Chapter 22—Engineering Responsibility

In February 1978, the Joint Logistics Commanders established a test and evaluation planning guidance *ad hoc* group to "assess the current joint testing environment, determine the best approach to resolve deficiencies in existing directives, and develop appropriate policy and guidance for greater commonality of test and evaluation effort." Direct results of the group are evident in proposed changes to current service regulations and compilation of a *Compendium of Test Terminology*. An *ad hoc* group for joint service testing was established for multi-service operational test and evaluation in July 1978 by the OT& E Commanders.

Now a fourth Joint Commanders initiative is a program manager's *Guide for the Management of Joint Service Programs*, approved on December 11, 1979. Developed by the Defense Systems Management College with Logistics Management Institute as the contractor, copies of this guide are available from DSMC-DRI-I upon request.

Joint service programs involve continuous, dynamic, and complex processes involving substantial areas for dispute. DOD policies and regulations provide only a rudimentary framework to resolve interservice issues, usually through negotiation and compromise.

Research Methodology

The objective of this study was to identify and analyze the most common joint service acquisition problems in order to provide alternative solutions for the program manager based upon lessons learned from other program managers. The approach consisted of a literature survey and personal interviews with the sixty-seven identified joint service program managers and their program staffs and service and OSD staff members involved in joint program acquisition policy formulation. The Joint Logistics Commanders' Joint Program Manager's Guide *Ad Hoc* Committee representing the DARCOM, NAVMAT, AFSC, and AFLC Commanders provided tremendous assistance and guidance in the research, preparation, review, and staffing of the guide.

Research Findings

Difficulties in joint program management derive from the disparities in the service requirements, differences in mission-derived priorities assigned, and varying policies, procedures, and regulations among the services. Requirements, program reviews, organization and staffing, financial management, engineering management, logistics, and test and evaluation were identified as problem areas related to joint service acquisition.

The basic document for any major acquisition program is the mission element need statement (MENS). The MENS, however, is new to DOD. Existing requirements documents in the services remain valid. The approach each service takes in preparing requirements documents, the level of detail, and the time these documents are required are very dissimilar. The services have basically added the MENS as an additional requirement to the USAF statement of need (SON), the USN operational requirement (OR), and USA letter of agreement (LOA) and letter requirement (LR)/required operational capability (ROC).

The acquisition strategy for achieving the programs goals may be the only integrating factor between the services, but only because each major program has a unique strategy. The program manager must recognize major constraints in time, money, personnel, and technology. The PM directs his efforts to reducing risk to an acceptable level through studies and analysis, prototyping, technology demonstration, and testing and evaluation. Achieving unanimity of opinion on the results of his attempts to reduce risk in a joint program may be hampered by differences in procedures among the services—issues such as competition, concept development, contract versus in-house, concurrency, contract types, multitude of contracts, etc. "The source of most joint service acquisition program conflict can be attributed to organizational interests and bureaucratic politics."[2]

Many joint programs are less than major, thus not subject to the DSARC review. Review and approval is retained by the lead service, but the PM is subject to a joint review process if he is to gain and retain support for his program.

The joint program structure depends on the emphasis and goals of the program, the desired relationships among the services, the role of OSD in the program and the phase of the program in the acquisition process. The wide variety of joint program organizations is depicted in Figure 2. The continuum also includes programs based upon a single-service requirement with other service taskings, data-sharing arrangements by a confederation of programs, and single-service programs with points of contact in the other service(s) or on-site liaison. Based upon these alternatives, the joint program manager must tailor his organization to the mission, functional relations with the executive and participating services, and extent of the responsibilities of the joint program office. Because of the increased interservice coordination and liaison activities, joint program offices require greater staffing than comparable single service programs.

The joint program manager's authority, responsibility, and accountability are derived from a charter issued by the executive service (exceptions are TRI-TAC and MEP which also have DOD directives as well as service charters). The charter must allow the joint program manager to accomplish trade-offs between cost, schedule, and performance based upon the requirements threshold; determine and allocate funding needs and obtain control over funds allocated to the program; and communicate directly with the other services' decision makers, if required, to resolve support problems. The charter must also address program resources and funding arrangements, definition of each service's responsibilities for program execution, relationships of the joint program with other programs and supporting organizations, and the chain of command for resolving program issues. Optional elements in the charter are the responsibility, authority, and reporting/rating official for the participating service(s) deputy program manager, reporting requirements, project office organization and staffing, creation of joint committees, establishment of joint operating procedures, and rating of all

Figure 2 CONTINUUM OF JOINT PROGRAM ORGANIZATIONS

military personnel

The joint program, to be effective, must establish control of all obligation authority. All obligational authority for the joint program should be transferred to the servicing host command (the joint program office is always a tenant organization, serviced by the host command), and a close working relationship established with the host comptroller. A forthright relationship should be established with excess funds returned to the comptroller as soon as it is ascertained that these funds are not needed. At some later date when the program manager has a genuine need for funds, he is more likely to get a sympathetic hearing from the comptroller.

Programming and budgeting functions should similarily also be centrally directed by the joint PM. The programming, budgeting, and allocation processes practices vary from service to service, as well as year to year within each service. Funding responsibilities for most joint programs is shared by the executive and participating services with funding subject to each service's assessment of priorities. There is always the possibility that one of the participants may unilaterally eliminate or reduce funds (RDT& E, procurement, O& M) to the program office. There are also differences among the services in their uses of various categories of funds or in funding responsibilities. The formula for sharing costs varies from program to program. An equitable method of sharing costs is to (1) have the executive service entirely fund the RDT& E program with budget priority support from the participating service(s), or split the RDT& E responsibility among the participants according to an agreed formula based upon procurement quantities; (2) provide procurement funds to meet each service's quantity requirements based upon the average cost of the unit, with funding of common items such as data and software prorated among the participants, (3) prorate funds for operations and support from a single service manager, based upon actual costs; (4) assign funding responsibility for military personnel in the program office to their military service; and (5) assure changes to meet requirements peculiar to one service and additional data requirements are funded by the particular service. One program manager solved the common configuration problem by having the participant requiring the change fund the unit price increases for the other services.

Because the services operate in different environments, are organized to accomplish different missions, and support their forces differently, the support concepts and logistic resource requirements vary. Estimates of support, investment, and O& S costs must reflect these variations. The differences in support concepts drive the program back toward individual service acquisition programs. There are differences in practically every aspect of support—using unit organization structure, levels of maintenance, and types of support available, occupational skills, training, facilities, TMDE, and supply environment. Some of these differences are significant enough to influence the preferred equipment design, especially maintenance characteristics. A joint maintenance concept should be developed by a Joint Integrated Logistics Support Planning Group. This group would necessarily include representatives from all user or user-representative commands of the joint services. Use of the logistics support analysis review (LSAR) techniques establishes logistic-oriented tasks directly related to reliability, availability, and maintainability and has a single integrated data base as a sole source of design related logistics data pertaining to the engineering effort.

Logistics planning tasks take longer and require considerably more work than a single-service program. Because logistics involves detail work, logistics issues normally cannot be resolved by escalation to a higher decision authority. Subcommittees or working groups are required for provisioning, training, LSAR, etc. A steering committee composed of key staff and management personnel among the services is required to provide logistics directives to the subcommittees or working groups. Finally, a high-level review committee is required to review and establish overall logistics policy that cannot be resolved at lower levels.

The engineering management area is clearly in the joint program manager's favor. Interservice and DOD cooperation has been developed toward the creation of common standards in engineering disciplines. Engineering changes are driven, however, by changes in systems requirements and technological advancement. Configuration management guidelines, as developed in SISMS, must be developed to systematically identify, evaluate, coordinate, approve, and implement changes in configuration.

The joint program manager is encouraged to "tailor" or "partition" the standards and specifications to suit the complexity and phase of the program. Tailoring or partitioning the standards and specifications can eliminate the unnecessary detailed specifications which are automatically called out by the citing of a general specification or standard. The aim of the process is to reduce the

cost- and schedule-driver specifications.

Control of the development of software has become a significant problem with the use of embedded computers in military systems. A significant source of difficulty in joint programs is that as equipment matures and goes through testing, user participation and experience come into play. In fact, the Air Force practice is to turn over software configuration management for mission equipment to the using command. Control by the joint program manager becomes more difficult. One of the most effective means of maintaining software configuration control in this environment is to maintain configuration control of software documentation. Early management attention to the development of software documentation is essential if the program manager is to manage software rather than have software development become an impediment to the system development.

Joint service configuration control boards should be chaired by the service having the prime responsibility, with participating services as members. Resistance to change must grow as risk decreases at each succeeding development milestone, after an early thrust for innovation and exploring of alternatives. The service configuration management control regulations, as well as SISMS, prescribe the means to systematically identify, evaluate, coordinate, approve/disapprove, and implement changes. The configuration control plan must address (1) the level of authority for control and expansion of this control as the design and testing progresses, (2) contractor's internal configuration management system, (3) change analysis, coordination between services, and approval procedures, (4) plans for auditing the configuration, (5) criteria for the product configuration baseline, (6) plans for production/producibility change testing, and (7) data elements of the work breakdown structure on which data will be collected.

Problems also exist in testing in the areas of conflicting Army, Navy, and Air Force development test and evaluation (DT& E) and operational test and evaluation (OT& E) regulations. Proliferation of separate service testing that slows the joint program and fails to provide new relevant information must be resisted. DT& OT is conducted to (1) demonstrate feasibility, (2) minimize design risks, (3) determine the design alternatives and trade-offs necessary to best achieve program objectives, (4) ascertain that the system design is complete, and (5) demonstrate that the system's military utility will justify production. Operational effectiveness and suitability issues must be addressed adequately before a production decision can be made. The operating environment is significantly different for the three services. Differences may exist in the performance envelop; designing to the worst case is not normally affordable or desirable. There are major differences in the environments, access to facilities, test equipment, and maintenance skills available at each level. Because of these differences, operational testing differences are most apparent. The program manager must recognize these differences and plan his testing accordingly to optimize testing accomplished in each phase. DT/OT II will, of course, cause him the most significant problems, but relatively minor issues can be addressed in a follow-on test and evaluation of the first Army, Navy, and Air Force operational units just prior to the initial operating capability (IOC) date. Planning, programming, and allocation of the proper category (6.2, 6.3, 6.4, procurement, or O& M) of funds for test and evaluation also represent a basic failing of the structure.

Conclusion and Recommendations

Nothing is more important to the success of a joint program than interservice agreement on requirements and funds. Such agreements may well need to be consumated at the service headquarters level, since it is here requirements are validated and funding priorities established. Methods and structures to resolve service conflicts over requirements and priorities are needed. USDR& E participation should not be overlooked, since they often generate the requirement for a joint effort and can provide a forum for conflict resolution, particularly if the conflict is over the cost of a joint effort to the services.

Logistics support analysis (LSA) deserves the highest visibility within the joint program office to tie together the elements of the integrated logistics support to a common data base. The standard integrated support management system (SISMS) must be instituted as early in the program as possible to include integrating SISMS into the data call, addressing logistics issues among the functional specialists, and controlling configuration changes.

Most importantly, micro-management must be avoided. The need to resolve requirements and funding issues at the service headquarters and OSD levels can quickly and even inadvertently lead to incursions into the program manager's domain. These must be avoided if program management integrity is to be preserved.

References

1. John S. W. Fargher, Jr., "The Requirements Determination Process Within the Department of Defense," *Eighth Annual DOD/FAI Acquisition Research Symposium Transactions,* May 2—4, 1979 (Fort Belvoir, Va.: Defense Systems Management College, October 1979), p. 119.

2. Colonel Norman A. McDaniel, USAF and Lieutenant Dino A. Lorenzini, USAF, *An Analysis of Joint Service Acquisition Programs,* Report of the Naval War College Center for Advanced Research (Newport, RI: Naval War College, June 1979).

ACCELERATING THE DECISION PROCESS IN MAJOR SYSTEM ACQUISITION

William G. Moeller

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ABSTRACT

The objective of this study was to ascertain how the management review process incident to DSARC milestone decisions affects the length of major system acquisitions and to determine what changes are needed in this process to accelerate major system acquisitions. Of the 13 programs reviewed, only 2 were adversely affected by the DSARC management review process. In both cases the impact was minor and attributable to delays in issuing the actual SecDef decision. It was found that the management review process tends to parallel the technical development of the system and its length is a function of the chain of command within the reviewing organization. It was concluded that the DSARC management review process does not have a significant impact on the length of the major system acquisition cycle and hence, recommendations on specific steps or aspects of this process are not warranted. It was suggested that further examination into areas such as funding problems, testing requirements and concurrency may prove useful in shortening the acquisition cycle.

INTRODUCTION

Acquisition cycles for some major weapon systems are now extending from 12 to 15 years and beyond. In this length of time perceived threats and technologies often change, and the results may be the deployment of obsolete systems. DoD's concern over the lengthening acquisition cycle has led to an explicit policy statement that one objective in major system acquisition is to "minimize the time from need identification to introduction of each system into operational use." (1)

The major system acquisition cycle consists of a sequence of activities leading to successful achievement of program objectives. These activities include: determination of needs, exploration and demonstration of the feasibility of alternative system design concepts, engineering development, test and evaluation, production, and deployment. Each of these activities may span several years and may be delayed by such factors as technological barriers, the adequacy and timeliness of available funding, and qualitative or quantitative change in the program requirements. The management review aspect of the process is often cited as a primary contributor to long acquisition cycles. For example, the Defense Acquisition Executive (DAE) has stated that the single biggest deficiency in the acquisition process is the long acquisition time and that "it's the management superstructure...in Washington that's strangling the process."(2) In addition, the Defense Science Board (DSB) in its Report of the Acquisition Cycle Task Force, March 15, 1978, indicated that delays in system acquisition decisions are caused by introducing further complications into the process itself, such as more levels of review and approval, and recommended that the number of prescribed steps be reduced.

OMB Circular A-109 establishes policies for major system acquisition by executive branch agencies. It requires heads of executive branch agencies to approve major system acquisition programs at their inception and to decide, at stipulated key points, whether or not a program is to be continued. DoD Directives 5000.1 and 5000.2 implement the requirements of A-109 for major system acquisitions within DoD. DoDD 5000.1 defines the key decision points for the Secretary of Defense: Program Initiation (Milestone 0), Demonstration and Validation (Milestone I), Full Scale Engineering Development (Milestone II), and Production and Deployment (Milestone III). DoDD 5000.2 establishes System Acquisition Review Councils at both the DoD level (DSARC) and the Service levels ((S)SARCs) to review major programs and advise the Secretary of Defense at the aforementioned milestones. Such reviews must be conducted for all major programs by the (S)SARC of the cognizant Service at Milestones I, II and III and by the DSARC at Milestones II and III. (DSARC reviews are also held at Milestone I for certain specified programs.)

The principal document used to record essential program information and to support the (S)SARC and DSARC reviews is the Decision Coordinating Paper (DCP). The processing, coordination, and review of DCPs constitute the major portion of the required management review process leading to DSARC milestone decisions.

The original objective of this study was to determine how the management review process in major system acquisition can be accelerated. Implicit in this objective was the assumption that the management review process contributes

significantly to the length of the acquisition cycle in DoD and that accelerating that process would necessarily accelerate the overall cycle. However, after initial investigation, the validity of that assumption came into question, and the study objective was therefore revised.

The revised objective was to ascertain how the elements of management review affect the length of the acquisition cycle and to determine if changes are needed in that area to accelerate major system acquisitions. The scope of the study was limited to the management review process incident to the DSARC decision milestones in a major system's acquisition cycle. Hence, the central question became whether or not the requirements attendant to the processing, coordination, and review of DCPs at both the Service and the OSD level adversely affected the length of the major system acquisition cycle. A secondary objective was to report on any other aspects of major system acquisition identified during the study that could be lengthening the overall cycle and might call for further examination.

There were three major phases to this study. The first phase was directed toward identifying the management review activities in the acquisition process prescibed by existing instructions, and thereby establishing the review process required in each Service prior to a DSARC decision.

The second phase was an examination of selected aspects of the acquisition history of current major programs in each Service. Table 1 lists the programs reviewed during this study. Recent exposure to the DSARC process was the primary criterion for selection. Of the 11 programs that had a DSARC milestone review in the period December 1977 through March 1979, 9 were included in the study sample. The major activity of this phase was interviews with Service and OSD personnel associated with the selected programs. The organizations contacted were: OUSDR&E; the Office of the Chief of Staff, Army; the Office of the Chief of Naval Operations; the Office of the Chief of Staff, Air Force; the Army Aviation Research and Development Command; the Army Troop Support and Aviation Readiness Command; the Naval Air Systems Command; the Naval Sea Systems Command; the Air Force Systems Command; and the Air Force Aeronautical Systems Division. Program offices within some of the above listed organizations were among those contacted.

The purpose of the second phase was to gain an understanding of the actual management review process used in each Service and its impact on the selected programs. During this phase, an attempt was made to answer the following questions:

1. Did the management review process adversely affect the length of the acquisition cycle?
2. If so, to what extent?
3. If warranted, how could the management review process be shortened or accelerated?
4. What other factors adversely affected the length of the acquisition cycle?

Our findings are summarized in the following section.

TABLE 1. PROGRAMS IN STUDY SAMPLE

	PROGRAMS	LAST DSARC MILESTONE
ARMY	ASH	- DSARC IA on Mar 23, 1976
	BLACK HAWK	- DSARC III on Nov 30, 1976
	DIVAD GUN	- DASRC II on Jan 5, 1978
	PERSHING II	- DSARC II on Dec 21, 1978
	SOTAS	- DSARC II on Aug 4, 1978
NAVY	AIM-7M	- DNSARC II on Apr 26, 1978; OSD Program Review on Apr 27, 1978
	HARM	- DSARC IIC on Feb 14, 1978
	LAMPS	- DSARC IIC on Feb 16, 1978
	PHALANX	- DSARC III on Sep 20, 1977
AIR FORCE	AMRAAM	- DSARC I on Nov 9, 1978
	EF-111A	- DSARC III on Dec 12, 1978
	GBU-15	- DSARC III on Sep 5, 1978
	KC-10A	- DSARC II waived; AFSARC III on Aug 30, 1978

Several terms used in the second phase of the study should be explained. First, certain factors (e.g., program funding problems) or aspects of major system acquisition (e.g., the management review process) are discussed in terms of "lengthening" or "delaying" or "adversely affecting the length of" the acquisition cycle. What this means is that had that particular aspect not been required or that factor not occurred, hardware for the program could have been delivered sooner to the user. Second, as used herein the term "management review process" encompasses the steps leading to a decision by the Secretary of Defense. The decision itself is not considered to be part of the management review process, but a proper exercise of management authority and responsibility in the acquisition process.

The final phase of the study was the development of conclusions and recommendations based on analysis and evaluation of the information gathered in prior phases.

SUMMARY OF FINDINGS

The DSARC management review process demands a great deal of a program manager's time and generates a sizable workload for the program office. However, of the 13 programs sampled, only 2 appear to have been adversely affected by the process, and in both cases the delays were minor (two to four months). Moreover, the delays were associated with issuance of the decisions after the DSARC meeting, not with the steps prior to it. One of these programs was also delayed because one of the DSARC principals had a scheduling conflict.

Interviews were conducted with both military and civilian personnel in three Services and OSD about programs with diverse hardware at different stages of development. Nevertheless, there was a consensus among the interviewees that the management review process does not hold up the technical progress of systems under development, and that elimination of the review steps leading up to a DSARC decision would do little to accelerate the acquisition cycle. The timing of the DSARC process depends on progress in the technical development of the system, and that is what consumes the time. Most program managers understand the OSARC process and plan for it accordingly. Thus, it was found that for the most part the management review process parallels the technical development of the system. The majority of the interviewees cited factors other than the management review process as contributors to prolonged acquisition cycles.

The length of the DSARC management review process (i.e., the number of review steps) is a function of the chain of command within each reviewing organization. To shorten the management review process, the chain of command would have to be shortened or changed. This is an organizational consideration and hence, beyond the scope of this study.

The DSARC management review processes required by existing regulations in each Service differ, especially in terms of the number of required steps and the degree of procedural detail. The Army is the only Service to have revised its regulations and instructions in order to stay current with OSD policy in this area. In addition, both Army and Navy programs are subjected to a number of interim staff briefings not required by existing regulations. However, regardless of how cumbersome or streamlined individual Service review processes appeared, they made no significant difference in the length of the acquisition cycle for the programs reviewed because the review processes parallel other acquisition activities.

A system's development time, and hence the length of its acquisition cycle, depends largely on the adequacy and timeliness of its funding. Seven of the 13 programs reviewed experienced funding-related problems. Over 30 percent of the interviewees indicated that inadequate program funding, including lack of funding stability, was the primary contributor to prolonged acquisition cycles. Funding-related problems can range from minor budget cuts to program stretch-outs to total elimination from the budget. Funding instability (e.g., changing estimates of planned available funds in out-years or differences in planned vs. actual funding amounts in a given year) can prevent the accomplishment of program objectives in the time originally contemplated. Many of the funding problems seem to stem from a lack of proper interaction between the DSARC process and the resource allocation process (i.e., the PPBS). Decisions made in one forum can be reversed in the other. For example, it was learned that the GBU-15 program was totally eliminated from the budget three weeks after it received the DSARC Milestone III production approval.

Six of the 13 programs reviewed experienced problems with changing system requirements. Lack of agreement within both the cognizant Service and OSD on the configuration and performance parameters required was cited several times as a significant cause of long acquisition cycles. Other instances of this problem include altering a system's design during the development stage by requiring additional technical capabilities, and indecision as to a system's potential operating environment. Inconsistency in system requirements can promote program instability, divert limited resources from more important activities, and lengthen the acquisition cycle.

Five of the programs reviewed appear to have been affected by testing requirements. (There was no attempt to assess if the delays due to testing were justified.) In addition, many interviewees mentioned the large amount of testing required prior to certain major program decisions as a prime contributor to the length of the acquisition cycle. Most major weapon systems are tested by at least three different organizations: the contractor, the developing agency, and the cognizant Service's independent operational test and evaluation (OT&E) group. Much of this testing is performed sequentially. As the Defense Science Board's Acquisition Cycle Task Force stated in its 1977 summer study, "what is really desired--and desirable--is <u>joint</u> testing but <u>independent</u> evaluation."

Only a few of the programs reviewed made use of planned concurrency in the various phases of development (i.e., accomplishing acquisition activities in parallel). Acquisition activities now performed sequentially could be performed concurrently for some programs without risk to the success of the program. For example, one of the programs reviewed is planning to have the logistics support work done concurrently with initial production, instead of during the development stage. Increased use of concurrency was considered by many of the interviewees to have potential for shortening the major system acquisition cycle. The Acquisition Cycle Task Force has pointed out that concurrency is standard practice in commercial business and that a certain amount of it can contribute to the shortening of the acquisition process.

CONCLUSIONS AND RECOMMENDATIONS

The Defense Science Board stated in its 1977 summer study that

> "there is a normal tendency to take this elaboration of the decision process as the cause of the delay (to the acquistion process) and to assume that streamlining the process would reduce

> the delays. On the other hand we may thereby be confusing cause and effect: the elaboration of the decision process may be only a Parkinsonian rationalization of the overall delays which actually stem from deeper causes."

The findings from this study support this statement. It was concluded, based on these findings, that the management review process incident to a DSARC milestone decision does not significantly affect the length of the major system acquisition cycle. For this reason, and because the length of each Service's review process is a function of its chain of command, any recommendations to eliminate review steps would probably have little or no impact on the length of the acquisition cycle, but could adversely affect organizational matters. In addition, it is both impractical and naive to suggest that certain levels in the chain of command should not be able to exercise the prerogative of reviewing programs under their auspices. Therefore, recommendations on specific aspects of or steps in the DSARC management review and decision process of each Service are not warranted.

However, there is nothing inherent in the management review process to prevent its causing program delays in the future. Consequently, attention should be paid to keeping the process within manageable bounds. The only effects of management review on the programs in the study sample were delays in issuing the Secretary of Defense decision or in scheduling the DSARC principals. It is recommended that OSD continue to schedule DSARC meetings well in advance in order to permit proper planning and that OSD attempt to issue all Secretary of Defense decision memoranda within three weeks of the DSARC meeting. This last recommendation coincides with the guidance in the latest draft revision to DoD Instruction 5000.2.

The Services should keep their individual instructions on the major system acquisition process up to date and aligned with DoD policy. It is suggested that OSD take action to require the Services to update their implementing instructions or regulations within four months of the effective date of any new revisions to DoD Instructions or Directives on major system acquisition.

The findings indicate that factors other than the management review process have a significant impact on the length of the acquisition cycle. Areas such as funding, testing and concurrency appear to hold greater promise for shortening the acquisition cycle. These areas involve complex issues which have been studied and debated for years. The intention here is not to recommend specific changes, but rather to suggest areas where further examination appears warranted, if shortening the major system acquisition cycle is a primary objective in DoD. It should be recognized, however, that there may be other objectives and reasons underlying the current DoD policy in these areas more compelling than shortening the acquisition cycle. The following is a discussion of the factors identified during the study as having potential for shortening the acquisition cycle.

As previously noted, many of the problems related to program funding result from improper interaction between the DSARC and PPBS processes. The current OSD initiative in the area of affordability of major systems is an attempt to improve this interaction, and it should be continued. In addition, other means of increasing the stability of program funding should be explored. One such means is multi-year funding for selected high priority programs. Although this concept is apparently unpalatable to Congress at present, it is possible that some limited application of it under the proper conditions might be approved at some future time. In any event, further research into the problem of program funding stability should prove very beneficial.

Another concept that should be examined is the establishment of a reserve to be used by OSD to finance start-up work on new programs immediately after approval of a Mission Element Need Statement (MENS). As pointed out in several recent reports on the acquistion process,(3)(4) there is no mechanism for funding new major programs other than the PPBS. Since it can take upwards of 18 months for a new program to break into the PPBS budget cycle, there is a built-in lag in the acquisition process subsequent to MENS approval. Establishment of a reserve or revolving fund to be used for financing new major programs upon MENS approval could possibly accelerate the acquisition cycle. Obviously, such a reserve would need to be tightly controlled at the OSD level and would need congressional support. Nevertheless, OSD should seriously evaluate this concept and determine under what conditions it would be logical and beneficial.

The testing area was repeatedly mentioned as a prime factor contributing to long acquisition cycles. Several efforts by OSD could help in determining whether a detailed review of testing requirements is needed. For example, an examination of 10 to 20 major systems to determine if the testing program resulted in substantive system changes could provide insight into whether all of the testing is necessary. Also, it could be beneficial to find out whether testing programs are being adequately tailored to the individual system by taking into account factors such as use of mature or off-the-shelf components, and performance of testing as early as feasible in the development cycle.

The sequential aspect of testing on DoD weapon systems is another candidate for further examination. It appears that opportunities may exist to shorten the acquisition cycle through consolidation of some testing and use of concurrent testing. OSD should evaluate this idea and determine under what conditions consolidated and concurrent testing seem reasonable. In

addition, OSD should consider the possibility of allowing performance of OT&E concurrently with the start-up of production for selected systems. Because of the large investment in a program by the time it reaches OT&E, outright cancellation at this point is seldom a viable option.

The wise use of planned concurrency can be beneficial in shortening the acquisition cycle. OSD should take a serious look at the concept of concurrency with the aim of developing guidelines which delineate the conditions under which concurrency seems logical. Such guidelines should take into consideration factors such as the urgency of need for the specific system, the technical advancements or risks embodied in the system, and the likelihood of a change in the military threat against which the system is to be deployed.

Akin to the concept of concurrency is the need to use a flexible approach to acquisition. Each system is unique in some way. Why must every program's acquisition process have the same four phases? Perhaps phases could be combined or elminated for some programs without much risk. There is a real danger that the acquisition process could become institutionalized to a point where it becomes rote, with little room for management judgment. Innovative and imaginative approaches to acquisition should be encouraged. Tailoring the process to fit the specific needs and circumstances of a program could provide a means to shorten the acquisition cycle. One of the programs reviewed during the study is utilizing some of these concepts and tailoring its acquisition strategy to the specific circumstances of the program in order to shorten its acquisition cycle. It appears that these efforts have been successful to date. OSD has also recognized the potential benefits to be derived from a flexible approach to acquisition in its latest draft revision to DoD Instruction 5000.2. Opportunities to shorten the acquisition cycle such as the ones mentioned above should be actively pursued.

REFERENCES

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A MULTICRITERION PLANNING AID FOR DEFENSE SYSTEMS ACQUISITION WITH APPLICATION TO ELECTRONIC WARFARE RETROFIT

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ABSTRACT

Multiple criteria approaches to decision situations are valuable due to the increasing importance placed on incorporating non-commensurate and conflicting objectives into the choice making process. Process algorithms for multiple objective optimization theory and multiple attribute utility theory motivate a combined methodology which utilizes the complementary aspects of both processes.

In this paper, results are presented of the application of this joint approach to a defense systems acquisition problem. Specifically, a paradigm for electronic warfare aircraft retrofit is developed using the combined multicriteria process. A set of criteria which can be used to evaluate, in a comprehensive manner, alternative system configurations is presented and used, with synthetic data, to illustrate the proposed planning aid.

1. INTRODUCTION

The retrofit of a particular aircraft with equipment designed for a mission which the aircraft was not originally designed to fly typically requires a large systems effort. Specifically, the retrofit of an aircraft with sophisticated electronic warfare (EW) equipment has historically involved inefficiencies and inadequacies including schedule and budgetary overruns and a lack of initially specified final product performance. Development of a useful combined multiple objective optimization theory multiple attribute utility theory based process (MOOT/MAUT process) seems a logical choice to ameliorate the difficulties of current electronic warfare aircraft retrofit design (EWARD) processes. These difficulties are felt to be representative of those encountered in defense systems acquisition; they are by no means unique to defense equipment acquisition however.

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**The opinions expressed here are those of the authors and do not necessarily reflect the views of the Department of Defense, any specific military service, or any individual within the Defense establishment.

The major contributions of this effort are the delineation of systems engineering process algorithms, the development of a combination methodology based on the complementary characteristics of multiple attribute utility theory (MAUT) and multiple objective optimization techniques (MOOT), the development of an efficient framework for EWARD through extension of the approach, and the generation of a set of criteria for evaluation of alternative retrofit systems in the defense systems acquisition cycle.

2. MULTIPLE CRITERIA DECISION THEORY

The MCDT approaches of MOOT and MAUT can both be utilized in a normative manner, which makes them suited for identifying policies which are aimed at providing solutions to decision situations. These MCDT approaches are comprehensive techniques for complex decision situations.

The MOOT approach is concerned with generating non-dominated solutions to a vector of objective functions. Information from a preanalysis effort is used to identify a vector of value functions which are then optimized using an appropriate technique. The results of this optimization process generally represent one or more sets of "efficient" solutions from which the decision-maker (DM) subsequently chooses the "best optimum". This "best optimum" selection by the DM has not received a proportional amount of attention as has the optimization aspect of MOOT. Our use of MOOT is primarily as an aid to alternative ranking as contrasted with its more typical use in optimization.

The MAUT approach requires the analyst to elicit preference information from the DM concerning the relative importance of attributes of proposed alternatives policies. This information is used to formulate a scalar social choice function which is used to score alternative policies. MAUT seeks to rank alternatives based on the decisionmaker's utility for the outcomes or attributes of those alternatives. MAUT, therefore, is intended primarily to be a decisionmaking aid. A principal difference between the two approaches is the inclusion of criterion or attribute weight elicitation in MAUT to form a scalar social choice function for evaluation. While neither approach is entirely new, the development efforts for both approaches have not reached full maturation (Starr and Zeleny, 1977).

The structural basis of both MOOT and MAUT processes produces a set of common characteristics. These characteristics include:

a. a set of objectives (generally non-commensurate and conflicting) which reflect the DM's values
b. a set of attributes for measuring attainment of objectives
c. a set of alternative actions or decision variables
d. an elicitation of preferences concerning a number of the attributes from the DM

This set of common characteristics leads us to expect the same quantitative solution from both MOOT and MAUT processes when they are applied to the same decision situation if we assume that the DM is consistent with respect to the preferences elicited in the MOOT and MAUT processes. Indeed this is the case because the MOOT process eliminates dominated sets of solutions which are not Pareto optimal. Surely none of these sets can be optimal in MAUT where Pareto optimality is a necessary condition.

MOOT and MAUT processes are both mental constructs to approaching multiple criteria decision situations and that for all intents and purposes, there are no fundamental differences in analytical structure between them (DeWispelare and Sage, 1980). There may be a number of behavioral differences however noted in actual practice which relate to the different effects of such factors as stress and contingency style upon each of the processes and the combined process.

When either MOOT and MAUT approaches are used, there is a commitment made by the using organization to dedicate the required resources toward producing a solution. Because of the structural similarity of MOOT and MAUT processes, much of the information required concerning a decision situation by either process is for all practical purposes identical. LIkewise the time requirement to carry out MOOT and MAUT processes is comparable because similar functions must be accomplished with the DM(s) and other stakeholders in both processes. There are organizational implications of the operational differences in MOOT which allow the DM to express alternative value scores prior to formation of the NDSS. In the case where contact between the analyst and DM is limited to separate short intervals, the MOOT process may be more efficient than the MAUT process because the analyst can accomplish part or all of the ranking process to form the NDSS between interviews. Much analysis can be done with just these alternative value scores and without knowledge of attribute or criterion weights (White and Sage, 1980). In MAUT, both the DM's value scores and criterion weights must be accomplished prior to ranking alternatives which may delay somewhat the identification of the optimal policy in the case of restricted DM-analyst interaction. Very often, limited contact with DM(s) and the other stakeholders necessitates certain assumptions such as linearity and risklessness as discussed by Edwards (1977). While these assumptions limit the types of multiple criteria analysis techniques which can be used, their presence often allows for a solution in a pragmatic manner. In these situations of restricted DM-analysis contact, the analyst is challenged to organize the interview, utilizing techniques such as prior construction of attribute templates for verification by the DM and rapid screening of decision alternatives, so that the essence of the DM's values can be rapidly elicited.

MOOT and MAUT have each developed as methods primarily directed at two different purposes. MOOT is efficient at optimizing in the multiple criterion case as well as determination of non-dominated sets from elicited attribute or criteria scores. MAUT is adept at incorporating the DM preference structure into the decisionmaking effort. We postulate that the most is gained by using each approach in a complementary fashion in the manner for which each was developed. In this way a multiple criteria approach takes on an air of synergism and the potential for close adaption to the varied cognitive styles of decisionmakers.

If it appears cost effective to use a MCDT approach to resolve the decision situation, then Figure 1 is an aid which can lead the user to an appropriate technique. The DELTA chart of Figure 1 indicates to the analyst and DM whether the combined MOOT/MAUT approach is appropriate for a specific decision situation. An abbreviated algorithm for the joint approach is shown in Figure 2. The deterministic/non-time varying case is described in this algorithm because of its simplicity and generality. The following efforts are accomplished:

a. A pre-analysis phase is accomplished to generate the input description and specification or decision situation issue formulation elements

b. A systems analysis/modelling phase is directed toward constructing the situation model so that impacts of the various alternatives policies will be "correctly" produced.

c. Identification of feasible alternatives is the next step prior to optimization.

The generation of a set of alternative actions from which to choose is accomplished in system synthesis. In an effort to cause the DM to think in a comprehensive and thorough manner, the analyst should encourage the DM to consider as many alternatives as possible. Analysts and others on the DM's staff may be of considerable assistance in this regard. Logical steps in identifying the feasible alternatives are to list the possible alternative acts and then eliminate the improper acts. This reduction of the decision space to include the feasible alternatives is usually accomplished to some degree by the DM (perhaps subconsciously) using some version of lexicographic ordering or elimination by aspects procedure in which one compares the alternatives by looking at specific attributes, and eliminates alternative policies which do not meet minimum requirements for one or more aspects of decision situation resolution. The analyst continues this refinement of alternatives with the DM until an appropriate set of alternative policies is produced. Exclusive use of elimination by aspects usually requires that the attainment levels of the attributes are continually made more restrictive until only one alternative remains. In our approach, a set of minimum attainment levels is specified and other means are used to select the optimum alternative. This generally allows a successful tradeoff be-

tween flexibility, time, and tractability.

d. Optimization of the multiple objective functions is then accomplished. Ranking of alternatives using multiple objective value functions and MOOT is required because a scalar social choice function (SCF) has yot yet been formed.

e. The elimination of dominated alternatives is accomplished to reduce the decision space to only those alternative policies which have attribute levels which are non-directed, bearing in mind a caveat concerning elimination of an alternative which is not dominated by a majority of other alternatives. The efficient set of the best candidate forms of the alternative policies then forms the NDSS. In some cases, it may be reasonable to form a "feasible essentially NDSS." For instance, Figure 3 shows a set of solutions for the two attribute case. The strict NDSS is composed of solutions a, b, c, d, e. But for a DM who values both attributes, solutions a and e are not very good (although they are non-dominated) and solution f is very good (although it is dominated). In this case, it would seem reasonable to form a feasible essentially NDSS composed of solutions b, c, d, f which should be examined closer for selection of the optimum.

f. The optional final policy selection phase is a MAUT exercise where the preferences of the DM are elicited to form a scalar SCF. This process is described by Keeney and Raiffa (1976), Edwards (1977), Sage (1977), and others. The SCF then becomes the scoring criterion by which the members of the NDSS are evaluated and ranked. The optimal policy is then identified and presented to the DM for consideration. There are many opportunities, we feel, for innovation concerning this phase of the effort and current research to this end (White and Sage, 1980) is in progress.

g. An analysis of results is conducted to evaluate the sensitivity of the solution to variation in parameters. Critical parameters are identified, and an improvement in the accuracy of these parameters are attempted. The final step in the algorithm is planning for implementation of the optimum policy.

This algorithm is iteratively applied until no significant change occurs in the results. This algorithm, which allows MOOT and MAUT to be used in individually specialized but complementary steps, appears more efficient than resolving the decision situation with either approach alone. Modifications to this algorithm due to outcome uncertainty, time varying relationships, and other factors are contemporary needs for research in this area.

The benefits of the combined MOOT/MAUT approach compared to either process are as follows: there is more efficient resolution of decision situations because of the complementary nature of the combined processes; this combined approach can be used if there is limited access to the DM because the interview time can be partitioned into elicitation of alternate act scores or utilities, and criterion or attribute weights elicitation, while allowing the analyst to continue in the modelling and optimization steps between these elicitations. The main cost of the combined MOOT/MAUT approach compared to either approach alone is an expected increase in computer resources utilized particularly as the number of attributes increases. We do not believe that there is an increase in required decisionmaker interaction; often just the converse will be the case. Table 1 presents comments on the costs and benefits of these approaches.

3. THE ELECTRONIC WARFARE RETROFIT PROCEDURE

The USAF is guided in the procurement of military equipment by various regulations and directives (eg., DOD, 1977a; USAF, 1966b). The U.S. Air Firce EW retrofit process starts with the identification by the using commands in group G-1, or the intelligence community, of a deficiency or need. Figure 4 illustrates the process. This deficiency can be a previously recognized weakness which now can be corrected through successful efforts of government laboratories or industrial contractors through the acquisition of a new systems. This deficiency or need is presented by the using command to Headquarters Air Force (Hq. USAF) in the form of a statement of need (SON), and this is where group G-2 becomes involved (USAF, 1978). If the initial estimate of system research, development, test, and evaluation (RDT & E) exceeds $75 million or $300 million in production, the program is designated a major systems acquisition. As a major systems acquisition, the Defense Systems Acquisition Review Council (DSARC) review program is required. The Mission Element Need Statement (MENS) is next generated which must identify the mission need in terms of the task to be performed, assessment of projected enemy threat, and existing DOD capability (DOD, 1977b). Hq. USAF reviews the MENS and forwards it to the Secretary of the Air Force (SAF) who approves it and sends it to the Secretary of Defense (SECDEF) for final approval, or redirects it for appropriate modification or termination. If the need is judged as legitimate and current by the SECDEF, the program is initiated (milestone 0) by authorization of funds for the Conceptual Phase.

A DELTA chart documenting the Conceptual Phase is illustrated in Figure 5. Funding is made available to a System Program Office (SPO) cadre in Group G-3 to define the acquisition problem, identify program objectives and goals, and alternative candidate systems. The SPO also develops models to evaluate operational considerations, acquisition approaches and associated risk factors. Using cost and performance trade-offs, candidate systems are evaluated to identify one or more alternatives for entry into the Validation Phase. Next, development of a Program Management Plan (PMP) is undertaken as the summary of the previous efforts. The PMP is used as the basic document defining pertinent aspects of the retrofit system. The PMP is used to prepare the Program Management Directive (PMD) which summarizes the previous efforts in the Conceptual Phase, and presents a plan for proceeding into the Validation Phase. Hq. USAF uses the PMD to generate the Decision Coordinating Paper (DCP) as input to the Air Force Systems Acquisition Review Council (AFSARC). AFSARC makes recommendations on the program and forwards these to the SAF.

If the DCP is approved, it is passed to the DSARC (milestone I) for action. Following recommendations by DSARC, the SECDEF is tasked with final decision on the program. If approval is granted, funding authorizes proceeding into the Validation Phase. The Conceptual Phase is purely a "paper" effort with no funding authorized for hardware.

The Validation Phase is illustrated in Figure 6. When the Validation Phase is authorized by the SECDEF, a SPO (G-3) is tasked with generating the basis from which one or more contractors are selected to go into the Development Phase. Validation is achieved through either a contract definition (paper design) or a prototype (hardware demonstration) approach. In the "contract definition" approach, usually two (or more) contractors are allowed to compete with each other in an attempt to further define amd refine the system. A Request for Proposal (RFP) is issued which initiates the paper study. The results of this phase are system specifications and a statement of work. A source selection team, including representatives from G-1, G-2, and G-3 selects the most attractive contractors from the competing group. A RFP is issued and funding negotiations for the Development Phase are completed with the selected contractors. In the "prototype" approach, a Development Concept Paper (DCP) from the Service Secretary (G-2) initiates the process. A formal RFP is distributed to industry, and a Source Selection Team usually chooses one or more contractors to fabricate a hardware version of the system under development. This hardware system is evaluated analytically in a demonstration or "fly-off" exercise. During this evaluation, a RFP is prepared for Full-Scale Development, and the most satisfactory potential contractor is selected for further development. In either contract definition or prototype approaches, a PMP is prepared next, followed by the DCP and PMD, and a DSARC board meets for milestone II(G-1, G-2, G-3) to judge the worthiness of the program to proceed. If the program is judged essential and proceeding satisfactorily, the SECDEF acts on the program. If the program is approved, a PMD (G-2) is sent to the SPO and funding is approved as authorization to proceed to the Full Scale Development Phase. Other alternative actions to proceeding into Development are to return to more validation, or cancellation.

The Full-Scale Development Phase provides the expanded engineering design, fabrication, testing, evaluation, and support planning for the selected system. The "user" and "supporting commands" participate in the Development Test and Evaluation (DT & E) and Initial Operational Test and Evaluation (IOT & E). The contractor negotiates for production during the testing process, and configuration audits (FCA and PCA) are accomplished subsequent to finalizing the system configuration. After this, any change in the system is rigidly controlled and must follow the formal Engineering Change Proposal (ECP) route. The results of the Development Phase are presented to DSARC at milestone III for review. If approval is granted and Office of the Secretary of Defense (OSD) funding procured, the program enters production.

In the Production Phase, the system is produced by the contractors and logistic support is procured. This by far is the most costly and time consuming phase up to this point.

The completed system is turned over to the user in the Deployment Phase by the Systems Manager (SM) in Logistics Command (AFLC). There the system is utilized and maintained until its retirement.

The process just described for EW retrofit of an aircraft is seldom followed exactly because of a number of complex factors pertinent to electronic warfare. There appears to be seven basic reasons for EW retrofit difficulties:

1. Electronic Warfare is a highly technological, expensive and specialized business.
2. There is insufficient communication between all stakeholders at all phases of the system cycle.
3. The decisionmaking structure is multilevel and semidefined.
4. Government policy makers to not operate in sufficient isolation from private industry and while this has many benefits it can have disadvantages as well.
5. Long range government policy is difficult to forecast.
6. The current funding directives (OMBC-109) encourage (and occasionally specify) dual-contractor development procedures for newly designed equipment and consequent funding and scheduling issues.
7. The contractor and retrofit program are often given flexibility with respect to cost and schedule commitments and this indirectly encourages program limitations, delays or cancellations due primarily to priority changes as contrasted with performance and cost issues.

These factors make the normal EW retrofit procedure difficult to implement. They point out the need for a comprehensive approach to the EWARD, such as that supplied by the MOOT or MAUT systems engineering methodology. These multiple criteria approaches allow the incorporation of a set of salient attributes in a way that allows one to address the requirements by individually considering factors which are affected by the impediments discussed previously. This flexibility is of significant value in a large-scale effort like EWARD. In EWARD, the need exists for an adequate set of criteria which can be utilized in the evaluation of alternatives. The development and subsequent incorporation of these criteria into the difficulties cited produce a cost effective product that will meet the needs of the users.

4. THE EWARD DECISION SITUATION AND APPLICATION OF THE MULTIPLE CRITERIA DECISION PROCESS

A major accomplishment of this research is in deducing whether or not a MCDT approach could ameliorate potential inefficiencies extant in a particular defense systems equipment acquisition. The specific application entailed applying the combined MOOT/MAUT approach to an EWARD situation in tne Conceptual Phase of the Defense Systems Acquisition Cycle. A pre-analysis phase was conducted in which three primary groups of stakeholders were identified. These groups were the

operations group, the government policy group, and the technical development and assessment group within the U.S. Air Force.

A set of twenty-one decisionmakers and advisors from the three groups identified above volunteered to take part in the effort. These participants were individuals who were currently involved in the design, production and procurement of EW equipment. Interaction with the participants was through a series of interviews. As expected, the objectives identified by the participants were found to be noncommensurable in the sense that no common measure (cost, volume, etc.) could be found. With the interaction of the DMs and advisors from the three stakeholder groups, a set of criteria which included the salient attributes of EWARD was established (Table 2). A set of alternative systems with respect to levels of the attributes was obtained from government and industrial sources. Data used in our example have been modified to incorporate the realism of a retrofit situation without identifying specific equipment. Preferences, utilities, and minimum acceptable attainment levels of the attributes were elicited from the groups to be used in the MOOT/MAUT process. Through utilization of the process, the decisionmaking group was able to identify an optimal alternative in an expedient manner. A validation exercise was performed on an actual system now in use to corroborate the developed EWARD approach as an efficient process for identifying a satisfactory retrofit configuration.

Two important features seen in this application effort are that this application methodology makes provisions for participation of decision makers, advisors, and experts at an early phase of EWARD, and the methodology used appears flexible enough to be applicable to any EWARD of the near future. The EWARD process was accomplished by use of the attribute template determined in this research and shown in Figure 7 together with the developed MOOT/MAUT algorithm.

7. SUMMARY CONCLUSIONS

The following conclusions can be drawn:

a. While there are operational and philosophical differences between MOOT and MAUT, both processes are mental constructs to approaching decision situations.
b. At the application level, both MOOT and MAUT approaches will allow identification of a strategically equivalent optimal policy, assuming the DM is consistent and the NDSS is complete.
c. The complementary phases of MOOT and MAUT are compatible for combination into a single methodology.
d. There are many interesting behavioral implications of a combined MOOT/MAUT process.
e. A MCDT approach has merit in an EWARD application, particularly in its early stages. The combined MOOT/MAUT approach should increase the efficiency of EWARD in a comprehensive manner for an overall time and resource savings in evaluating alternate system configurations.
f. The experimental subject group used in this research viewed the MOOT/MAUT framework presented as an acceptable and desirable approach to this specific defense systems equipment acquisition situation (EWARD).
g. Careful assessment of preferences and corroboration of the scaling constants in the aggregated utility functions of DMs and advisors is critical to identify the optimal system configuration.

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Table 1

Comments on Multiple Criteria Approaches

Approach	Cost of Using	Benefit of Using
MOOT	DM may not feel involved in certain aspects of the process such as the optimization and formation of NDSS	Presents the candidates for optimal alternative in the form of a NDSS
MAUT	Requires detailed elicitation of the DM's preference structure	Ranks all alternatives in terms of scalar performance index
MOOT/MAUT	Generally requires more analysis time (and computer time) because of the comprehensive approach	A comprehensive approach that incorporates the DM into several phases which should increase the acceptance of this approach by DM's. May require less total DM involvement then either process used separately.

Table 2

Criteria for an EW Retrofit System

1. Technical: EW Aircraft Aerodynamic Performance
   a. EW System Weight
   b. EW System Volume Required
   c. EW System Power Required
2. Economic: EW Retrofit System Life Cycle Cost
3. Military: Retrofit System Electronic Warfare Performance
   a. Aircrew Performance
   b. Number of Threats Degraded
   c. Number of Threats Defeated
4. Political: National Policy Satisfaction

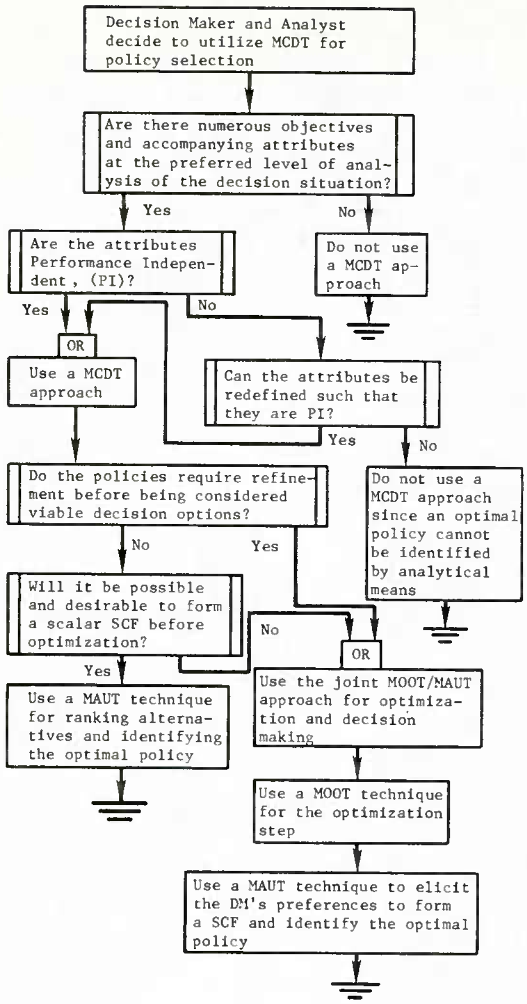


Figure 1. MCDT Approach Selection For a Decision Situation

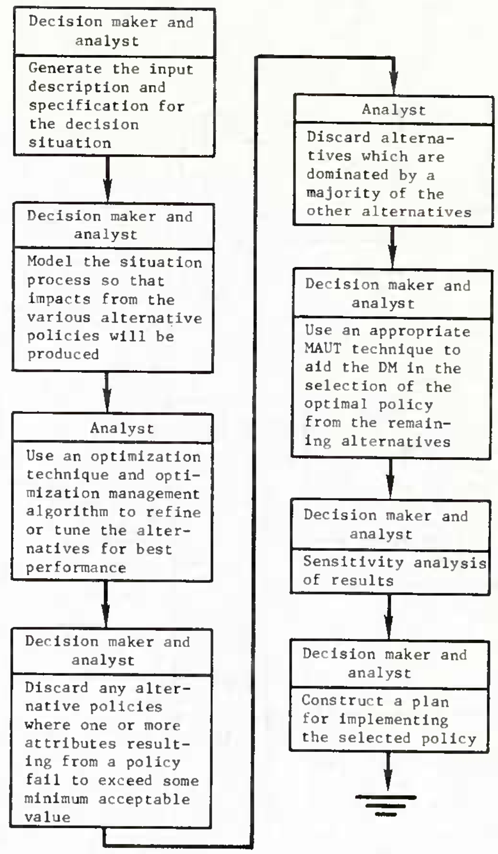


Figure 2. Abbreviated DELTA Chart Of The Combined MOOT/MAUT Algorithm

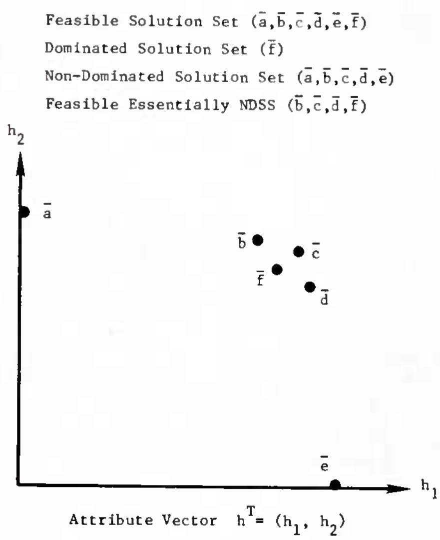


Figure 3. Feasible Essentially NDSS

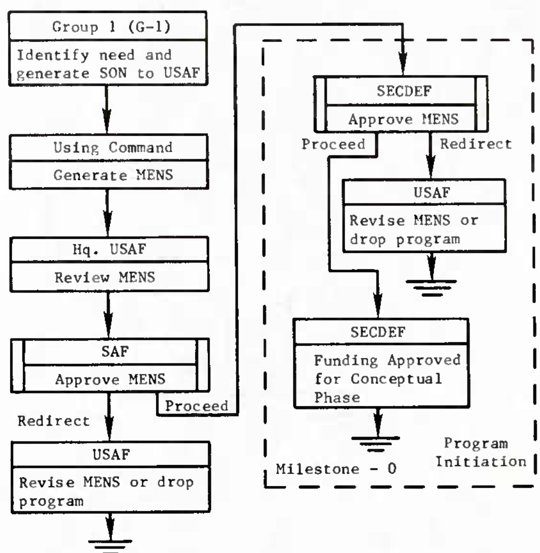


Figure 4. Defense Systems Equipment Acquisition Program Initiation

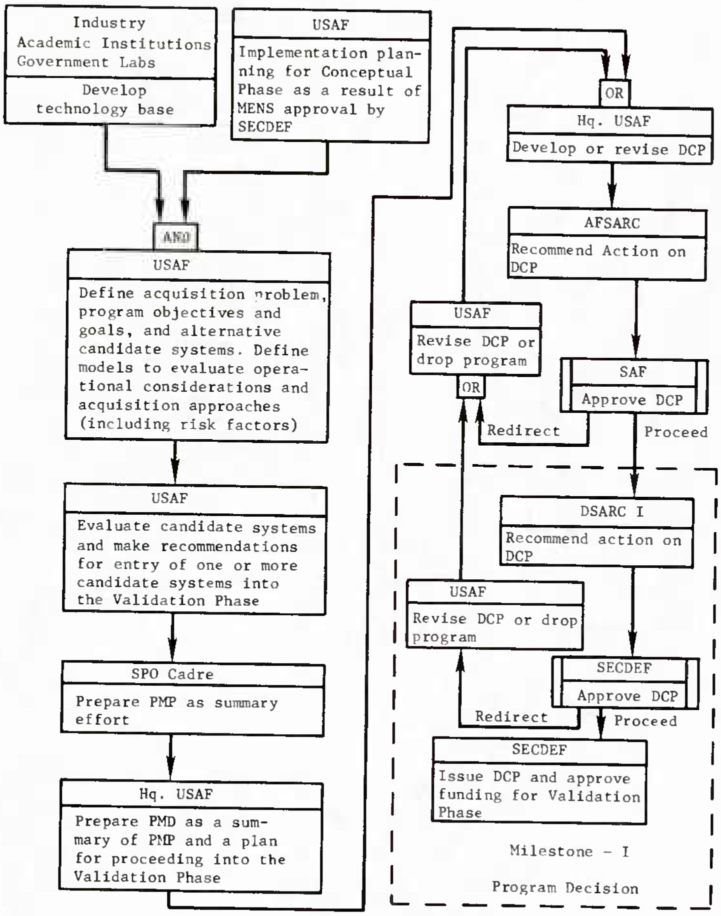


Figure 5. Defense Systems Equipment Acquisition Conceptual Phase

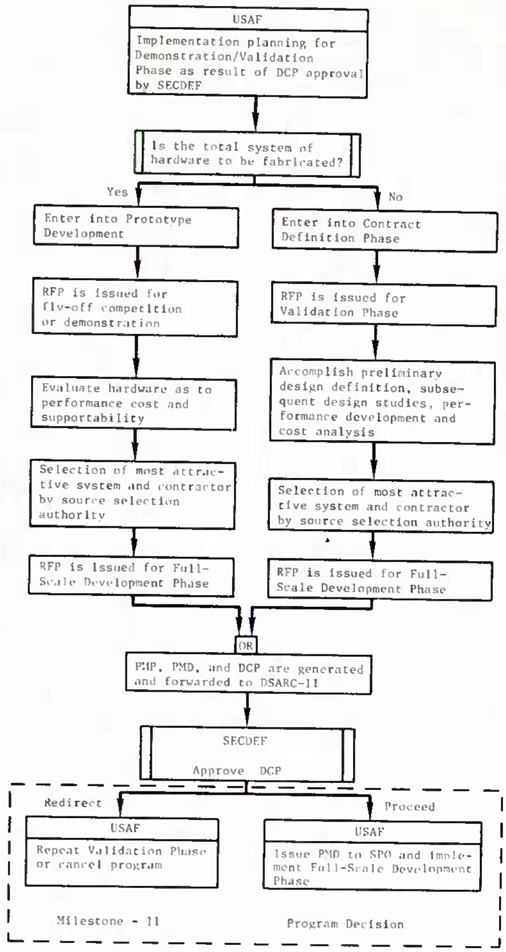
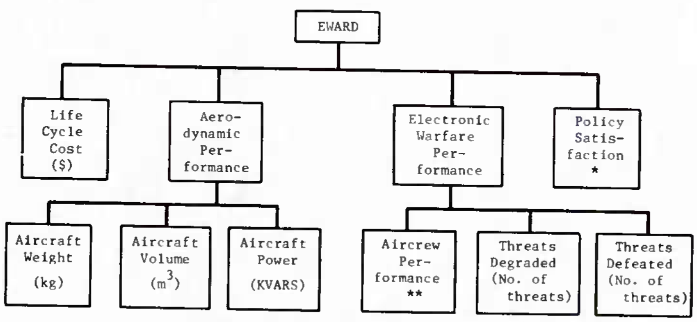


Figure 6. Defense System Equipment Acquisition Validation Phase



** Direct Assessment
* Direct Performance Measure

Figure 7. Attribute Template For EWARD

SYSTEMS ENGINEERING METHODOLOGY FOR DEFENSE SYSTEMS ACQUISITION

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ABSTRACT

This paper investigates the management of systems acquisitions for the Department of Defense (DOD). It indicates how the DOD can apply systems engineering techniques for a more effective approach to decisions involved in developing and procuring DOD systems. Based on an analysis of the existing policy structure of the DOD for acquiring new systems, a model is developed for the activities and major decision points of that system's engineering methodology. The nature and the structure of the decision process provide specific areas where a systems engineering methodology could be applied most beneficially. After the criteria for choosing the appropriate systems engineering tools and techniques are established, a methodology is developed with specific analysis procedures which are dependent on the stage of the acquisition process and the nature of the decision under consideration. A systems engineering team with specific functions and characteristics is suggested as a means by which the methodology is implemented.

1. Introduction

During the late 1960s and early 1970s, systems-acquisition efforts within the Department of Defense (DOD) were confronted with a number of significant problems. In 1969, the General Accounting Office (GAO) conducted a survey of thirty-eight major weapons-systems programs and found projected costs-to-completion 15 percent higher than the original contract cost figures. In particular, two aircraft-acquisition programs, the C-5A and the F-111 programs, had received a good deal of unfavorable public attention due to cost overruns. Operational requirements for the C-5A program were overspecified; this limited design trade offs and led to significant cost overruns. The F-111 fighter program experienced technical problems and unprecedented cost growth from approximately $3 million per unit in 1966 to almost $15 million per unit in 1970. These problems were caused by a variety of factors, including ineffective program management on the government's part, poor DOD/ contractor relationships, overcentralization of systems-acquisition management within the Office of the Secretary of Defense (OSD) and poorly defined operational requirements.

In 1969 the new Republican administration came into office with Melvin Laird as Secretary of Defense and David Packard as his Deputy. Both Laird and Packard viewed what they found in the Defense systems-acquisition area with alarm. It was clear that a major reorganization of the systems-acquisition process was required. Mr. Packard, the official responsible for all Defense research, development, and procurement, assumed this task.

In May 1969, Packard established the Defense Systems Acquisition Review Council (DSARC), which represented a management system for major Defense systems acquisitions. The mission of the DSARC was "to review major and important Department of Defense systems-acquisition programs at appropriate milestone points in their life cycle." Top-level DOD managers were to sit on this board, review and evaluate the programs, deliberate among themselves on program alternatives presented by the services, and make recommendations to the Secretary of Defense on the various program alternatives. In addition to establishing the DSARC, Packard also implemented several other revisions to the systems-acquisition process, including development of decentralized managment guidelines, clarification of OSD responsibilities, adoption of the "fly-before-you-buy" concept, formal publication of new acquisition policies and encouragement of new contracting procedures.

During this same period of time, procurement policies of the overall federal government had also come under close scrutiny. In the early 1970s the Commission on Government Procurement studied these policies and issued a report in 1972 that documented a number of recommendations in this area. These recommendations have evolved into a revised set of procurement policies presented in OMB Circular A-109, Major Systems Acquisition, which was issued by the Office of Federal Procurement Policy(OFPP) on April 5, 1976.

Circular A-109 defined a major system as "That combination of elements that will function

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The opinions expressed here are those of the authors and do not necessarily reflect the views of the Department of Defense, any specific military service, or any individual within the Defense establishment.

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together to produce the capabilities required to fulfill a mission need." Major programs are those that "are directed at and critical to fulfilling an agency mission, entail the allocation of large resources and warrant special management attention." The A-109 directive was developed to set forth policies in several keys areas as follows: the strengthening of the program-management function, communication with Congress early in the acquisition process, the designation of an acquisition executive for each agency, the expression of needs in mission terms, the exploration of alternative systems, and the reservation of four major program decisions for the agency head.

The DOD directed the implementation of the policies of A-109 with two directives, 5000.1 (Major Systems Acquisitions) and 5000.2 (Major Systems Acquisiton Process), which were issued in January 1977. These directives established an overall DOD systems-acquisition program as one that has a projected research, development, test, and evaluation (RDT&E) cost of $75 million or a projected procurement cost of $300 million. In keeping with the policies of A-109, the directives reserved four key major-program decisions for the Defense agency head (Secretary of Defense):

1. Milestone 0 - Decision for Program Initiation (approval of need and advancement to conceptual phase);
2. Milestone I - Decision to Proceed to Demonstration and Validation;
3. Milestone II - Decision to Proceed to Full-Scale Development;
4. Milestone III - Decision for Production and Development.

In accord with the policies originally established by Deputy Secretary of Defense Packard, the DOD directives required the establishment of the Defense Systems Review Council (DSARC) with a membership of top-level-DOD managers and responsibility to review major programs and make recommendations to Secretary of Defense prior to major decision milestones I, II, and III. These DOD directives also established the (Service) Systems Acquisition Review Council ([S]SARC) with a membership of top-level managers at the service headquarters. A (S)SARC was established at each service headquarters to review major programs and make recommendations to each service secretary for the decision process at milestones I, II, and III prior to consideration of the program by the DSARC and Secretary of Defense.

The DOD directives also required that two separate documents be developed for each major program. The Mission Element Need Statement (MENS) is used to document the mission need and includes a statement of the need in terms of mission-element tasks, a projection of the enemy threat, an identification of the existing DOD capability to accomplish the mission, a listing of constraints for the problem, and a program plan to identify and explore competitive alternative systems. The Decision Coordination Paper (DCP) is developed or updated prior to milestones I, II, and III. It includes a number of program considerations, including the updated MENS, acquisition strategy, business plan, management plan, areas of program uncertainty, resources required, test-and-evaluation plan, program issues, DSARC and (S)SARC recommendations, and Secretary of Defense decisions and directions. These documents play key roles in the systems-acquisiton process and in the operations of the DSARC and (S)SARCs.

2. Organizational Goals for Defense Systems Acquisition

The DSARC reflects the value system, operative within DOD, related to the systems-acquisition process when it pursues its primary (top-level) goal "to acquire a set of Defense capabilities which are adequate to implement national policies." Several DSARC subgoals contribute to accomplishing this top-level goal, including: to be responsive to the lead of Congress, to be guided by the directives and policies of the executive branch, to be concerned for a viable defense industry, to foster effective systems-acquisition-management capabilities, to be concerned for international security matters, and to develop the best overall program of systems acquisitions. The (S)SARCs have a similar set of goals except that each also assumes the role of "advocate for the institutional values of each particular service."

In pursuing the upper level goal of developing "the best overall program of systems acquisitions," the DSARC and the (S)SARCs consider other subgoals, which contribute to its accomplishment. These subgoals are: to insure that only the minimum set of systems-acquisition programs are approved as necessary to meet national-defense requirements, to induce a flexible approach to major systems acquisitions, to minimize systems-development time, to induce standardization and interoperability, to insure that MENS and DCP are fully developed and properly documented, and to identify critical issues and evaluation factors for each program. All of these subgoals are important in the systems-acquisition decision process.

3. Formulation of the Issue or Problem

This study addressed the possibility of developing a systems-engineering methodology to support the systems-acquisition decision process. A problem definition for this study is:

> To determine how the Defense systems-acquisition process may be improved using the techniques of systems engineering.

The emphasis of this study is directed toward the four major-decision milestones (0, I, II, and III), the operation of the DSARC and (S)SARC advisory boards, and the use of the Decision Coordination Paper (DCP) and Mission Element Need Statement (MENS) within the overall DOD-policy framework.

4. Analysis of the Issue

Initially the existing policy structure for the systems-acquisition process can be analyzed with emphasis on the phases, activities, and decisions of the process. The phases and activities of the systems-acquisition process may then be compared

respectively, to the various phases and steps of the systems-engineering framework. It is then demonstrated that there is a respective pairwise relationship between the phases, activities, and discipline requirements of the systems-acquisition process and the phases, steps, and knowledge requirements of the systems-engineering framework. These comparisons are shown in Illustrations 1 and 2.

Using the systems engineering framework, the nature and structure of the Defense systems-acquisition decision process can be examined to identify analysis areas where the application of a systems engineering methodology would be most beneficial. The goals of DOD in systems acquisitions are particularly important here. Selection criteria and organizational considerations for choosing appropriate systems engineering tools and techniques for use in the methodology are identified. A methodology with several specific analysis tasks may be developed to address requirements analysis and definition and the four major-decision milestones. The analysis procedures for these tasks are dependent on the particular "stage" of the acquisition process and the nature of the decision under consideration.

4.1 Criteria and Organizational Considerations for Applying Systems Engineering

The identification of the criteria for applying the systems engineering tools and techniques is important to the development of a systems engineering methodology for the DOD's systems acquisition. However, organizational characteristics must also be considered to understand how a systems engineering methodology can be used for the systems-acquisition process.

A criterion is a standard, rule, or test by which a judgement of something can be formed. The criteria for selecting an appropriate analysis tool must incorporate the key characteristics of the systems acquisition program to be evaluated. These key characteristics are identified when the acquisition program is viewed in the context of the systems engineering morphology. Key program characteristics and criteria are:

1. Characteristic: Data Availability for Programs

Criterion: Analysis methods must be appropriate to the quantity and quality of available data.

2. Characteristics: Stage of the Acquisition Process

Criterion: Analysis methods must be consistent with features and needs: such as risks and uncertainty, and tradeoffs between quantitative and qualitative elements of the specific stage of the acquisition process.

3. Characteristic: Program Objectives

Criterion: Analysis methods must be consistent with the overall objectives of a program.

4. Characteristics: A Step in the Analysis Effort for the Program

Criterion: Analysis methods must be appropriate to the particular logic-dimension step being analyzed within the systems engineering framework.

5. Characteristic: Extent of the Resources Required for the Program

Criterion: The effectiveness and reliability of the analysis efforts must increase as the resource inputs to the program increase.

The above criteria, which must be adapted to the specific program being evaluated, are important in selecting the tools and techniques to be used for a systems engineering study. The second major factor in determining the nature, type, and degree of analysis to be performed is the organizational environment. In the DOD context, several organizations, including the System Program Office, the Service Headquarters, and OSD, could evaluate an acquisition program.

The following organizational considerations affect the nature, type, and degree of an analysis selected to support decision making:

1. Predisposition of the organization to use analysis procedures.

2. Position of the analysis unit within the organization.

3. Background and experience of the decision makers. Their educational and professional backgrounds influence the degree to which the decision makers accept analysis procedures. Those with some technical background are usually willing to consider at least some sort of analysis assistance. Analysts must know the backgrounds of the decision makers.

4. Availability of decision makers. Time is a critical factor in any manager's professional day. Therefore, an analyst must adapt the analysis procedure to available time of the decision maker. Analysis procedures that require excessive managerial time are not likely to be used.

5. Mechanism used to transfer the results of the analysis to the decision makers. The procedures associated with the decision process are important in determining what type of analysis procedures should be used. The one-shot briefing in which only the results of the analysis are presented cannot accommodate complex analysis procedures; those analyses which cannot be grasped by the manager in a short, one-half hour briefing will not be used. On the other hand, if pre-briefings, informal conferences, or working groups are held first then more complex analyses may be used and acceptance is increased.

6. Criticality of the decision to the organization. The depth, extent, and nature of the analysis effort should be related to how important a particular decision is to the organization. Although the analysts should be aware of the decision makers' values, they must also be sensitive to the organization's value systems. Resources assigned to a particular program are not the only criteria for determining the importance of that program. Traditional mission-oriented needs, such as, tactical aircraft development

for the Air Force, and external political influences are two other criteria for measuring a program's importance.

7. Availability of resources for analysis. The availability of resources for analysis, including qualified analysts, technical/administrative support personnel, and computer facilities, is a key factor in determining the type and extent of analysis. Managers for analysis units should be keenly aware of the planning and budgets of the organization so that ample provisions are made for future analysis efforts.

8. Mode of organizational operation. The type of analysis to be performed must be related to the type of policy roles being assumed by the policymaker(s) within the organization.

4.2 Emphasis of Systems Engineering Methodology

Those areas of the overall Defense systems-acquisition process that should be emphasized in developing a systems engineering methodology may be identified from several perspectives: First, the perceived value system of the DSARC/(S)SARC panels may be examined to see how a systems-engineering methodology could assist the panel members in objective attainment. Second, the potential scope and focus of the methodology may be considered. Third, the structure and nature of the systems-acquisition process may be used to identify the specific problems for analysis that are of significant importance to management and particularly responsive to analysis efforts.

The first major area of emphasis to be identified is the development of the MENS. This document presents the results of the initial problem-definition step of the systems-acquisiton process. It is also used as the basis for approving new starts and is, therefore, a critical document. Because of the importance of this document, efforts to improve the format of the MENS should be rewarding. The first task of developing the systems-engineering methodology is to outline a more rigorous but yet flexible format for the MENS.

This initial task in developing the methodology involves two of the recommended DOD systems-acquisition policy initiatives covered in the observations on the nature of the systems-acquisition process. Specifically, this task is related to the recommended policy initiatives on formalizing the de facto mission-analysis phase into an official phase of systems acquisition. The task also relates to the policy initiatives for a more clearly defined problem-definition approach to the MENS.

Two of the other recommended policy initiatives follow from observations on the nature of the systems-acquisition process. These are : (1) the adoption of a more flexible overall approach for the process and (2) the integration of the OMB A-109 policies into the programming requirements of the PPBS and the congressional budget cycle. Since these issues have been considered by OSD and are included in the revised versions of DOD Directives 5000.1 and 5000.2, they are not addressed again in this paper.

The second major area of emphasis for the methodology is that of trading off the various potential programs early in the acquisition process. A very subtle type of tradeoff currently takes place at the Milestone 0 decision point. The mission-element-need becomes a yardstick for measuring requirements; the existing capability is measured against this yardstick. If the capability falls short of the yardstick, then, almost by definition, then some new start is required whether it is a completely new acquistion program or a major modification.

The problem, of course, is that the programs are not traded off, one against the other, until further into the systems-acquisition cycle when funding requirements are more readily identifiable. They are traded off when funds are constrained and with little management control. Therefore, the second task of developing the systems engineering methodology is to establish a procedure for evaluating and selecting the programs to be approved for official program initiation.

The final major area of emphasis for the methodology indicated by our observation, on the nature and structure of the acquisition process, is that of addressing the major-decision Milestones I, II, and III. Two types of decisions are considered at Milestones I, II, and III that could be analyzed with systems engineering procedures. The first type deals with evaluating and selecting alternative-candidate solutions to be advanced to the next phase of the acquisition process. This decision begins in the systems-program office and continues through the DSARC/(S)SARC process to the OSD level. The second type of decision is the go/no-go determination for an overall program to proceed to the next phase. This decision is usually forwarded through the (S)SARC and DSARC with recommendations to the SERVSEC and SECDEF, respectively. The first type of decision provides input to the second decision.

The relationship of the two types of decisions to the major-decision milestones and their importance to the overall systems-acquisition process are given in Illustration 3. This shows the similarity between major milestone I and II where both types of decisions must be considered. When the nature of the systems-acquisition process is considered as a stage approach problem, the decisions at Milestone I and II are made when there is still risk and uncertainty in the program and during the transition from qualitative to quantitative data. The decision situation at Milestones I and II may be contrasted to the situation at Milestone III. At the latter, only one type of decision must be made--the go/no-go determination for production. This decision is also made at the end of the development effort when risk and uncertainty are normally lowest and when quantitative data is most available.

Therefore, four separate areas have been identified for emphasis in the systems-engineering methodology. Each area of emphasis has an analysis task associated with it that is addressed in the development of the methodology. These analysis tasks are:

1. To develop a more rigorous and well-defined MENS;

2. to develop an analysis procedure to trade off newly identified programs (as represented by their MENS) early in the systems-acquisition process;

3. to develop an analysis procedure to support the DSARC/(S)SARC decision process at major-decision milestones I and II;

4. to develop an analysis procedure to support the DSARC/(S)SARC decision process at major-decision milestone III.

5. Development of the Systems Engineering Methodology

In the previous section, four specific problem areas of the systems acquisition decision process were selected for emphasis in the systems engineering methodology. Each specific problem area must be addressed by a separate task to develop appropriate analysis procedures. The four tasks developed for the analysis procedures are:

5.1 Task #1: To Develop a More Flexible, Better-Defined Documentation Process for MENS

The MENS is intended to document the operational need for a new or improved mission capability. A mission-need arises from a projected deficiency (or obsolescence) in an existing system, a technological opportunity, or an opportunity to reduce operating cost.

The significant changes in the overall development of operation requirements with the advent of the OMB A-109 and the MENS have been in the processing and approval of the requirements document. Previously, this document was approved by the separate services; now the MENS must be approved by the SECDEF. Because the requirements for the MENS are not as clearly defined as they could be, the characteristics of the mission-element need may not be documented in the most efficient possible way. This task will present an analysis procedure for a more clearly defined mission-element need.

Developing and documenting the MENS is the first general step, formulation or input description and specification, of the systems-engineering framework for the mission-analysis (program planning) phase of the systems-acquisition process. The MENS is the foundation document for the possible approval and implementation of a major systems-acquisition program. It is the basis for the major-decision Milestone 0 and also must be reviewed and updated at each subsequent major-decision milestone to insure that the operational need is still valid.

Based on the program characteristics, there are two important considerations: data availability and program objective. Data availability is limited in quantity and quality; the program objective at this point is to clearly define the problem in an integrated, identifiable, and visible manner. The availability of sufficient resources for analysis is particularly important to this task.

From the operational standpoint, it is assumed that an emerging mission-element need requires a clearly identified, properly developed, and meaningful document. It is also assumed that there are service personnel who have a qualitative understanding of the mission area and are willing to develop a MENS. Validation of the analysis procedures is not dependent on any strong underlying theoretical assumptions. However, it is assumed that the various sets of problem elements (i.e., alterables, constraints and needs) can be identified and the interactions among them determined.

The vast majority of the work required to develop the MENS could be accomplished at or below the service-headquarters level. Some services have requirements commands to carry out much of the analysis effort. Inputs to the threat assessment must come from the various intelligence agencies, such as, the Central Intelligence Agency (CIA), Defense Intelligence Agency (DIA), and the National Security Agency (NSA). The inputs for existing capabilities could come from the operational and logistical commands of the services.

The top-level managers in OSD or the service headquarters would have very little involvement in the initial analyses of this task. However, as preparation for the MENS advanced, top-level DOD managers should become more actively involved. This involvement in the analysis effort would provide the decision makers with the necessary background for an evaluation of the MENS as described in the next task.

The systems engineering teams to be used at the service headquarters could be responsible for providing technical support to the various groups involved in developing the MENS. Finally, they would review each MENS prior to its submission to the SERVSEC and SECDEF. This review should be designed to insure consistency in technical approach, format, content, and level of detail. This team would then assist the decision makers in understanding the analysis procedures required to develop the MENS.

This approach to MENS development should not cause significant increases in the costs or time to accomplish the overall process. The existing operational-requirements analysis personnel, assisted by the projected systems engineering teams, should be able to develop and document a MENS using the suggested approach. Once personnel become familiar with the standarized analysis approach of systems engineering, the MENS-development time should be shortened. The existing question as to what constitutes a MENS would be alleviated by this approach.

The recommendations embodied in the projected analysis procedure relate only to the development procedures and format for the MENS. There is no intent here to revise the MENS processing and approval cycle. Therefore, the policy implications are minimal and relate only to the requirement to revise DOD Directives 5000.1 and 5000.2 to reflect a systems engineering approach to developing the MENS.

5.2 Task #2: To Develop an Analysis Procedure to Trade Off Newly Identified Mission-Element Needs Early in the Systems Acquisition Process

This task addresses the development of an analysis procedure to provide means of evaluation at the major-decision Milestone 0. This evaluation would enable the tradeoff of newly identified mission-element needs and determine if a program should proceed to the conceptual phase. The task is addressed in the DSARC objective:

> To insure that the minimum set of systems-acquisition programs necessary to meet National Defense requirements are approved and the low priority, least affordable systems are cancelled.

The recommended approach to this evaluation process has several steps. First, semi-annual MENS submission dates would be established; as a draft MENS (potential programs) is submitted by a service, it would be assigned a number specifying the particular year and group. At the next six-months-review period it would be considered. Second, on a semi-annual basis, OSD would review and evaluate all the MENS (potential programs) using the standardized evaluation criteria and procedures developed below. Finally, programs showing sufficient merit would be advanced to the conceptual phase.

This approach will be particularly beneficial during the next several years as all potential programs go through the MENS process for the first time. The approach would provide important features to the systems-acquisition process. It would at least enable an attempt to be made toward trading off the candidate programs and determining their relative priority. This approach should secure the objective of developing only the required minimum set of systems-acquisition programs and cancelling the low-priority programs. Finally, each approved systems-acquisition program would be assigned specific year groups which would allow it to be more effectively integrated into the Congressional budgetary cycle and the PPBS.

The procedure outlined in this task addresses two of the general steps of the systems-engineering logic dimension. The impact-assessment step is addressed by the structuring of the problem, criteria identification, and program-evaluation efforts associated with the task. The output-specification step is addressed by the decision process used to select the programs to be advanced to the conceptual phase.

Based on the program characteristics, two important considerations are: data availability and the stage of the acquisition process. Data availability at this point is rather limited and data are qualitative. Two organizational considerations are important in selecting an analysis procedure: First, the availability of the analysts must be considered because much of the structuring of the analysis problem will, of necessity, have to be done within OSD where the decision to approve the programs is to be made. Second, the availability of top-level OSD decision makers must be considered. It would be inappropriate to select a procedure which placed unjustified demands on the professional time of these decision makers.

This analysis procedure which will support mission analysis and integration could result in:

1. A set of comprehensive checklists that would qualitatively describe the various aspects of each program under consideration.
2. A derived priority list for all the programs under consideration.
3. An assessment of the potential programs that had not met a preselected set of standards and were deleted.

This procedure would increase the ability to discriminate among the various potential programs and more efficiently evaluate their viability and overall contribution to the national defense.

Several steps would be required to assess the various potential programs by using a checklist procedure: First, a preanalysis effort should be directed toward identifying and defining the evaluation problem. This step should include the needs, constraints, alterable quantities, and objectives. Evaluation areas and associated factors would then be determined. Each factor would have levels of goodness associated with it dependent on the evaluation area. A baseline subset of factors and levels of goodness would be established as the minimum acceptable standard for the approval of a program. The decision maker would then assess each factor in relation to each potential program and determine what level of goodness could be achieved. This process would be carried out for all potential programs until a comprehensive checklist of factors has been compiled. These completed checklists would then provide a basis for determining if a particular program met the minimum acceptable standard for approval to advance to the conceptual phase. The checklists would also provide a means for the decision makers to discriminate among the potential programs and establish a priority listing of programs for approval.

The actual analysis effort to support this task could be carried out jointly by the services and OSD. The services could suggest evaluation areas and factors; however, the final structuring of the checklists should be done within OSD.

Top-level managers in the OSD would, of necessity, be involved in developing and filling out the checklists and would make recommendations to the SECDEF on a potential program. This could be done by a simple change in operational procedures without a revision of existing policies. The SECDEF would then a make a final determination on the approval of a specific program based on its MENS and the recommendations derived from the checklists.

The systems engineering team to be used within OSD would be deeply involved in the initial phases of this analysis task. It would be responsible for coordinating the overall development of checklists, including the consistency, reliability, and validity of the various evaluation

factors. The team would insure that the decision makers were properly educated on the purpose, intent, and employment of the checklists. Once the checklists were fully developed, the team would assist the decision makers in applying them to the evaluation process for the potential programs.

This procedure, which requires a good deal of an analyst's time and dedicated support, would also require additional time from the decision makers until standardized checklists are fully developed. However, once the evaluation process has been fully implemented, the decision makers would not be contributing an excessive amount of time to this decision function. The checklists should complement and amplify the MENS, thereby providing a more concise and well-defined decision package for the top-level OSD managers to consider.

The only significant policy implication associated with this task is the requirement to establish semiannual due dates for the MENS. This requirement could be fulfilled by a revision to DOD directives 5000.1 and 5000.2.

5.3 Task #3: To Develop an Analysis Procedure to Support the DSARC/(S)SARC Decision Process at Major-Decision Milestones I and II

This task addresses the development of an analysis procedure that will support the DSARC/(S)SARC decision process at major-decision Milestones I and II. Although there are two distinct decision points to consider, they are quite similar. They both occur during that portion of the overall systems-acquisition process when there is a good deal of risk and uncertainty with the program. This is also the period in the acquisition process in which there is a transition from the availability of qualitative to quantitative data.

Another similarity between major Milestones I and II is that the same types of decisions are required to be made at both points. The first decision deals with the evaluation and selection of alternative candidate solutions for advancement to the next phase of the acquisition process. The second decision deals with the go/no-go determination for the overall program to proceed to the next phase. Because of the similarities between major-decision Milestones I and II, the same type of analysis-support procedures may be used for both.

The procedure outlined in this task addresses two of the general steps of the systems engineering logic dimension. The analysis or impact-assessment step is addressed by the structuring of the problem, criteria identification, and program-evaluation efforts associated with this task. The output-specification and interpretation step is addressed by the decision process for selecting the alternative candidate solutions to proceed to the next phase and making the go/no-go determination for the overall program to advance to the following phase.

Based on the program characteristics, there are three important considerations affecting the selection of an analysis procedure: availability of data, stage of the acquisition process, and the extent of the resources to be committed to the program. More data are available at these decision points than at the Milestone 0 decision point, but, because of the stage of the acquisition process, much data are still qualitative. The commitment of significant resources is required for a program to advance to the subsequent phase. Consequently, the analysis procedures selected to support these decision points must have sufficient depth to justify the commitment of these significant resources. The following organizational considerations are important: how critical is the decision to the organization, how available is the decision makers' time, and how available is the analysis-support. Basically, the significance of the decision should be correlated to the decision maker's time and the analysis-support. Because the decisions of Milestones I and II lead to the approval of a system for full-scale development, an exacting analysis procedure is justified to support the decision-making process at these two milestones.

This analysis procedure should produce:

1. A preference ranking of the candidate alternative solutions and selection of the top ranked solution which should be advanced to the next phase.

2. A determination of whether or not the overall program should be advanced to the next state (phase).

This procedure would enhance the ability to discriminate among the various candidate alternative solutions and between the merits of approving or not approving the overall program for advancement to the next phase.

From the operational standpoint of DOD, it is assumed that a set of alternative candidate solutions associated with a specific acquisition program requires evaluation to determine which should be advanced to the next acquisition phase. It is also assumed that a go/no-go determination must be made concerning whether the overall acquisition program should proceed to the next phase.

The actual evaluation of the alternative candidate solutions would begin in the systems-program offices. These program offices, and other service elements, could assist in identifying and developing the evaluation areas and factors. The systems-program offices could use the analysis procedure noted above to arrive at their initial recommendation concerning which alternative candidate solutions are to enter the next phase. However, to support the DSARC and (S)SARCs decision processes, much of the analysis for this task would have to be carried out within OSD and at the several service headquarters. These councils should at least validate the recommendation and make their own decisions on the go/no-go determination for the overall program. Therefore, the structuring of the decision problem, the final development of the project scoring sheets, and the actual use of the scoring models would have to be accomplished within OSD and the several headquarters elements.

The members of the DSARC and the (S)SARCs would be involved in several phases of the analysis effort. Initially, they would need

to become familiar with the process to be used; then they should be involved in identifying and developing the evaluation areas and factors. Finally, they would have to evaluate the alternative candidate solutions and the overall programs.

The systems engineering teams recommend for OSD and the several service headquarters would be deeply involved in supporting this procedure throughout its use. Initially, the team members would have to educate the decision makers (the DSARC/(S)SARC members) in the purpose, intent, and employment of the procedure. The team members should coordinate the development of the evaluation areas, the factors, and the associated evaluation procedure for the factors. Finally, the analysts should assist the decision makers in using evaluation aids.

This procedure would require a good deal of an analyst's time and associated funding support. Initially, the decision makers would need time to familiarize themselves to some extent with the evaluation procedure and evaluation aiding approach. Once the evaluation process is fully implemented, the decision makers would only need to evaluate and select the alternative candidate solutions and make the go/no-go determinations for the programs. This function could be accomplished in approximately the same time that is now devoted to the evaluation and selection process.

No policy revisions would be necessary to implement this analysis procedure. Certain procedures in the present decision process would need revision, however.

5.4 Task #4: To Develop an Analysis Procedure to Support the DSARC/(S)SARC Decison Process at Major-Decison Milestone III

This task develops an analysis procedure to support DSARC/(S)SARC decision process at major decision Milestone III. Only one type of decision needs to be made at this milestone--the go/no-go determination for the overall program to advance to the next phase. The decision at this milestone is whether to produce and deploy the system. During the previous acquisition phase, the service responsible should have fully developed the single alternative candidate solution which would now be considered for production. Risk should, therefore, be at its lowest point and the number of evaluations factors should be reduced as there are no alternative candidates involved. However, the commitment of resources will be high for both the production and operational deployment phases.

The procedure outlined in this task addresses the general step of output specification and interpretation. The decision under consideration is a go/no-go determination. Previous steps in the systems engineering logic dimension must, of course, be carried out to provide a foundation and framework for this particular decision.

Based on the program characteristics, important considerations are the stage of the program and the extent of the resources to be committed to the program. At this milestone, a great deal of quantitative data should be available to support analysis. The resource commitment is large and should be complimented with a thorough analysis. This major-decision milestone, from an organizational standpoint, is critical to the service involved and to the DOD. It decides some subset of the next generation of Defense systems. Therefore, it must be as carefully analyzed as possible in accordance with the availability of decision makers' and analysts' time.

This analysis should produce:

1. A model, typically a decision tree, to represent the actual situation at major-decision Milestone III.

2. Elicitation of DOD management values or utilities for the outcomes of various decisions.

3. Determination of an optimal course of action, so that the decision makers, the DSARC/(S)SARC members, known, based on their own utility functions, whether or not to produce the system.

4. An analysis of the sensitivity of the best course of action to errors in the data.

This procedure would enhance the ability of the decision makers to discriminate between the decision alternatives of going or not going to the production and deployment of the system. This would also enable the decision makers to discern the probability of success of the system during production and deployment.

The actual evaluation of the systems acquisition programs should begin in the systems program offices. These offices could do much of the preanalysis. However, the bulk of the analysis would have to be carried out within OSD and at the service headquarters because the decision makers, the DSARC/(S)SARC members, would have to work closely with the analysts, the members of the systems-engineering teams to carry out the suggested procedure. Members of the DSARC and the (S)SARCs would be deeply involved in several phases of the analysis effort. They would have to work closely with the analysts to structure the decision problem and to identify possible alternate decisions. They would also have to supply the analysts with a variety of answers to questions about the relationship of alternatives to outcomes, the probability of the occurrence of outcomes, and the value to the decision makers of the various outcomes. The DSARC/(S)SARC members should have sufficient educational background, managerial experience, and R&D knowledge to contribute effectively to the analysis procedures as respondents to elicitation questions.

The initial implementation of this analysis procedure would require time from both analysts and decision makers because the decision situation would have to be structured in detail so that both analysts and decision makers would clearly understand the problem. Much of this problem structuring would not have to be repeated each time a program was evaluated. However, the use of this analysis procedure would still require more time of decision makers than is currently being devoted to these types of decisions. The improvement in the deci-

sion-making capability should compensate for the additional time required of the decision makers.

No policy revisions would be necessary to implement this analysis procedure. Implementation would require that certain procedures in the decision process be revised. Much of the analysis effort described above would be accomplished prior to and outside of the formal DSARC/(S)SARC proceedings. However, the results of the analysis efforts would be used during the formal DSARC/(S)SARC proceedings to support the formal decision process. The decisions, which resulted from the proceedings, would be documented in the decision coordinate paper (DCP). This decision vehicle would then be processed in accordance with the procedures previously discussed. Some portion of the analysis supporting each decision would be included in the DCP when it was forwarded to higher authority.

6. Implementation of the Methodology

The analysis procedures which constitute the systems engineering methodology for the Defense systems-acquisition process are outlined in previous sections. These analysis procedures, or others which could be developed at a future date, are of little value unless they are effectively implemented. This section addresses the general area of implementation, specifically, the implementation of the methodology developed in the previous section. The following topics are discussed: the consideration of a major barrier to effective implementation, a recommendation for the formation of a systems engineering team to minimize this barrier and to implement the methodology, and the identification of general characteristics and functions of the team. Finally, the means for measuring the effectiveness of the systems-engineering methodology once it is implemented will be evaluated.

Many problems could inhibit an analysis procedure from being effectively using to assist in the policy and decision-making processes. Several of these inhibiting factors are: the lack of quantifiable information available on which to base decisions, the unique nature of the organization of problems, and the lack of resources for analysis efforts, including qualified personnel. However, a major barrier to using analysis procedures for establishing policies and making decisions is the typical separation between the managers and the analysts within an organization. In many cases, their activities and functions do not interrelate. They may not be motivated toward common goals, and communication between the two groups may be poor at best. These gaps between the decision makers and policymakers and analysts need to be bridged if managers are to gain the greatest possible benefits from analyses.

A multidisciplinary systems engineering team could potentially bridge this gap. These teams could be employed in R&D by assisting in the analysis required to carry out the several steps and phases of the systems engineering methodology. The systems engineering teams could also act as brokers between other analysts, decision makers, policymakers, and other parties at interest.

The systems engineering team operates with these parties at interest to draw out issues, questions, and answers. Its primary role is to bridge the gap and to serve as a broker between these parties. The team acts as an information broker, as a mediator of technical matters, as an interpreter of analysis efforts, and as a synthesizer of management guidance. The need for this team becomes even more critical when there are several parties at interest at separate locations.

A systems engineering team must have several distinctive charactertistics if it is to function as a broker to bridge gaps effectively. Members of the team, particularly the leader, should possess several characteristics: multidisciplined, well educated, mature and experienced as analysts, experienced in operations or management, outgoing in professional relationships, trustworthy, and innovative.

A systems engineering team, filling the role of a broker to bridge the gap between parties at interest in defense systems acquisition, should perform several functions:

1. To be cognizant of ongoing analysis efforts within the organization. This requirement is particularly important as systems acquisition concerns large R&D programs prior to major-decision milestones.

2. To monitor and assist in the implementation of standardized analysis procedures directed by organizational policies. This does not mean being responsible for the implementation efforts, but for being aware of how they are proceeding.

3. To advise management on overall analysis practices and procedures. If the organization has analysis efforts being carried out in a variety of locations, analysis practices and procedures could be standardized.

4. To keep the analysis groups informed of policy revisions that could impact analysis procedures.

5. To translate the results of internal analysis efforts into management information. In many cases, the products of the analysis groups should be translated for management so that full value may be gained from the analyses.

6. To interpret the results of other organizations' analyses for management. Sometimes analysis efforts external to the organization must be evaluated. The teams should then provide management with concise and valid assessments of the impact and meaning of the external analysis efforts.

7. To be an advocate of the systems-engineering approach and analysis. This does not mean to be a proponent of a particular alternative or algorithm but it does mean to be positive in discussing the merits and pitfalls of systems engineering and its tools and techniques.

8. To be able to educate management to the value and proper use of analysis procedures and to the limits of analysis.

9. To carry out critical analysis procedures that have major policy or decision-making significance to the organization.

Specific functions that these teams could perform in implementing the systems engi-

neering methodology on the service-headquarters level and within OSD are:

1. To assist OSD in developing an overall systems-acquisition-analysis policy for DOD.

2. To assist service headquarters in implementing systems-acquisitions analysis policies and methodologies to insure uniformity in implementing the procedures of the methodology.

3. To assist the service headquarters in preparing for specific DSARC major-decision milestones.

4. To assist in the education of the DSARC members in the theory, procedures, and practices of the systems-engineering methodology.

5. To assist in the development of the actual analysis structure for the DSARC program evaluation, selection, and approval. This should include identifying the criteria and factors necessary for an evaluation of the candidate system alternatives and the overall program. Assisting DSARC members in developing their own value and utility functions to evaluate the program should also be included as well.

6. To assist the DSARC members in carrying out the actual trade offs involved in evaluating the major systems-acquisition programs, including how various operational policy matters could be revised as a function of the acquisition of new Defense systems.

7. To assist the systems-program offices and subordinate commands in implementing the system-engineering methodology for systems acquisition.

8. To assist the systems-program offices in preparing for specific (S)SARC major-decision milestones.

9. To assist in the learning process of the (S)SARC members in the theory, procedures, and practices of systems engineering.

10. To assist in developing the actual analysis structure for the (S)SARC program evaluation, selection, and approval.

11. To assist the (S)SARC members in carrying out the actual trade offs involved in evaluating major systems-acquisition programs.

Each of the service headquarters and OSD have major staff sections primarily concerned with research, development, and acquisition. Systems engineering teams could be located in these major staff sections. To insure brokerage and communication between the team and the policymakers or decision makers, the manager of the systems engineering team should report directly to the senior official managing the staff section.

Redundancy, feasibility, and validity of requirement are questioned when the suggestion is made to establish yet another analysis unit. However, there appears to be no current standardized DOD systems engineering methodology to assist in the decision process for major systems acquisition. In addition, no analysis unit in the several locations noted above appears to be performing the full set of functions described for the systems engineering teams. Therefore, such teams would not contribute to the redundancy of functions.

The cost of implementing the systems engineering methodology and the systems engineering teams appears minimal. Some slight revisions in the policy dealing with systems acquisitions and a number of procedural changes would be necessary. But, the actual funding required would be primarily in the area of the qualified systems engineering personnel and the necessary technical and administrative support. Smaller systems engineering teams of four to seven members could address a specific systems-acquisition program as it approached a major-decision milestone. Normally only four or five programs would require close analysis at any one time. Therefore, an overall systems engineering team of approximately twenty five people at each of the major headquarters appear sufficient implement the methodology and perform the brokerage functions previously outlined.

The following measures of effectiveness, for evaluating the benefits of implementing the methodology and forming the systems engineering teams, are suggested:

1. The number of MENS developed, processed, and approved for active programs should increase. If the requirements for the MENS are more clearly defined, then they will be more readily completed. This will enable all programs to be on equal footing, thereby insuring a greater degree of equity in the evaluation and selection process.

2. The number of areas where operational requirements are ambiguous should be reduced. More clearly defined MENS should result from implementation of the methodology and its problem-definition aspects. More clearly defined problem statements should reduce areas of conflict between and duplication of requirements.

3. The overall projected funding for the completion of all programs could hopefully be reduced. The absolute number of programs should be reduced with this introduction of procedures to trade off the various programs early in the acquisition process. This should also lead to a reduction in projected overall funding.

4. The variance among the conditions of programs appearing before the DSARC/(S)SARC should be reduced. The methodology will identify key evaluation factors critical to each state of the decision process. The highlighting of these factors should lead to more consistent program performance.

5. The number of programs failing or requiring major revisions in the phase after a specific decision point should be reduced. As the methodology is implemented and improved, greater consistency should develop between program approval and program performance. As the methodology evolves, decision makers should be better able to determine which key evaluation factors are the best predictors of future program performance. This would, of course, be a long-range means of evaluating the programs and the implementation of the methodology.

7. Conclusions

Based on the material developed in this paper, the following postulates and conclusions are drawn:

1. The systems-acquisition process is multidisciplinary in nature and may be appropriately modelled as a problem involving the various phases and steps of the systems-engineering framework.
2. The algorithms and techniques of systems engineering may be applied to the systems-acquisition process and decisions associated with this process.
3. The nature intent, and impact of the decisions required at each major-decision milestone of the systems-acquisition process is different. All stem from the perceptible value systems operative within the OSD and the several service headquarters in relation to the DOD systems-acquisition decision process.
4. The systems-acquisition process may be modelled as a stage-approach problem with normally decreasing uncertainty, increasing fund requirements, and the increasing availability of reliable quantitative data as the process moves forward from phase to phase (stage to stage).
5. Organizational considerations are important in determining the type, nature, and amount of analysis effort that may be applied at each step of each phase within the systems engineering methodology for systems acquisition.
6. Each step of each phase associated with the DOD systems-acquisition decision process could benefit by the application of systems engineering analysis efforts.
7. Effective implementation of the methodology could be significantly enhanced by the formation and proper use of systems engineering teams working with top-level managers within the OSD and the several service headquarters.
8. Systems engineering teams could potentially fill useful roles as brokers to bridge gaps between parties at interest in defense systems acquisition to better achieve mandated objectives for national security and peace in this important area.

8. References

A number of DOD documents are cited in the body of this paper and will not be repeated here. Two of several works which discuss systems engineering methodology are:

Sage, A. P., Methodology for Large Scale Systems, McGraw Hill Book Co., New York, 1977.

Sage, A. P., (Ed.) Systems Engineering: Methdology and Applications, IEEE Press, New York, 1977.

ILLUSTRATION 1

COMPARISON OF THE LOGIC-DIMENSION STEPS OF THE SYSTEMS-ENGINEERING MORPHOLOGY WITH THE ACTIVITIES OF THE FOUR PHASES OF THE SYSTEMS-ACQUISITION PROCESS

	Systems-Acquisition-Phase Activities			
Systems-Engineering Logic-Dimension Steps	Mission Analysis	Conceptual	Demonstration and Validation	Full-Scale Development
Problem definition	Mission need identification	Define acquisition problem	Define systems problem	Define production problem
Value-system design	Identify mission need in terms of mission element	Identify program goals and objectives	Examine and validate program goals and objectives	Examine and validate program goals and objectives
System synthesis	Identify known-solution candidates	Identify candidate-system alternatives	Validate and refine system or program alternatives	Valide projected system alternatives
Systems analysis	Develop enemy-scenarios for time frame of required capability	Develop models to evaluate operational consideration, acquisition approaches	Develop modes to evaluate system or program alternatives	Develop models to evaluate projected system
Optimization	Assess impact of not acquiring or maintaining	Evaluate candidate-system alternatives	Evaluate system or program alternatives	Evalute full-scale development model
Decision making	Milestone 0 (MENS approval cycle)	Milestone I (DCP approval cycle)	Milestone II (DCP approval (cycle)	Milestone III (DCP approval (cycle)
Planning for action (implementation of next phase)	Implementation of conceptual phase	Implementation of demonstration-and-validation phase	Implementation of full-scale-development phase	Implementation of production-and-deployment phase

ILLUSTRATION 2

THE TIME-DECISION PHASES OF THE SYSTEMS-ENGINEERING MORPHOLOGY COMPARED TO THE PHASES OF THE SYSTEMS-ACQUISITON PROCESS

Systems-Engineering Time-Dimension Phases	Systems-Acquisition Life-Cycle Phases
Program planning	Mission analysis and development of MENS
Project planning	Conceptual
	Demonstration and validation
System development	Full-scale development
Production	Production
Distribution	Deployment of phase in
Operation	1. Operation/support 2. Maintenance/repair 3. Modification/retrofit
Retirement	Retirement or phase out

ILLUSTRATION 3

TYPES OF DECISION CONSIDERED AT DECISION MILESTONES I, II, AND II

Major-Decision Milestone	To Evaluate and Select Alternative Candidate Solutions to Advance to Next Phase	Go/No-Go Determination to Advance Overall Program to Next Phase
I Approval to proceed to demonstration-and-validation phase	Most critical because of number of alternatives to be considered	Less critital than Milestone III; projected fund requirements are lower, production decision is not made
II Approval for production and development	Less critical than Milestone I; less alternatives are considered	Most critical; approval to proceed should not be granted unless production is very probable
III Approval for production and deployment	Not required	Almost as critical as Milestone II; final review before funds for production and deployment are committed

PRODUCTION RATE AS AN AFFORDABILITY ISSUE

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ABSTRACT

Investigation into the relationship between production rate and production cost for defense systems indicates significant variations in cost as a function of production rate. Thus, production rate becomes an important term in the affordability analysis equation. Based on empirical data, a rate/cost model has been developed which will provide planning information of sufficient accuracy to assist in the selection of appropriate production rates. This model can be applied to a wide range of defense systems.

Application of the rate/cost model can also provide insight into program related questions such as:

- Variation in production program costs for different production rate/time profiles
- Variation in the number of systems which may be procured with a fixed level of funding
- Cost impact of program stretch-outs
- Costs associated with maintaining a "warm production base"
- Effects on the number of systems which may be procured with changing levels of program funding

INTRODUCTION

The issue of production rates for defense systems has recently been given increased emphasis as an important element of systems affordability. This emphasis is not only evident within the Department of Defense, but also in the Congress[1], and the General Accounting Office[2].

The latest draft of Department of Defense Instruction 5000.2[3], titled "Major System Acquisition Procedures" requires that an analysis of the variation in unit cost with production rate be presented to the Defense Systems Acquisition Review Council (DSARC) at Milestone II (Full-Scale Development), and Milestone III (Production and Deployment). This requirement establishes the need for a method to explore the relationships between production rate and production cost.

This paper proposes one method for estimating the rate/cost relationship based on empirical data points which are unique to each weapon system. Methodology for performing the analysis is explained, and an example is given using a hypothetical aircraft program. The accuracy of this method is sufficient to provide useful planning information. In order to simplify the arithmetic operations required, a computer program has been devised and is enclosed as Appendix A.

Among the reasons why unit cost is reduced as a function of increasing production rate, amortization of fixed overhead costs is perhaps the most important.

METHODOLOGY

The proposed method for examining production rate/cost relationships involves the following steps:

- Determine specific rate/cost data points
- Fit a least squares line through these points
- Establish the production rate options to be analyzed
- Use unit cost estimates calculated from the least squares line to determine the funding requirements for each year of each option
- Sum the funding requirements for each production rate option
- Compare the totals for the different options

Point values for the rate/cost relationship can be established by several methods. The most accurate method is to use contractor's proposals. If this data is not available, in-house estimates may be used. As a worst case, one contractor supplied data point can be used with an assumed "industry average" slope for the rate/cost line. Even this latter method can yield results that are useful for planning purposes. Figure 1 shows the concept of fitting the data in least squares form.

Calculations involved in fitting the least squares line can either be done manually, or with the assistance of a computer. Most computer time-sharing services offer pre-programmed least squares curve fitting routines. Calculation of the correlation coefficient or coefficient of determination is of value in establishing the strength of the rate/cost relationship. These coefficients serve as indicators of the probable accuracy of the estimates obtained.

Most of the empirical data that has been examined to date exhibits a best fit to the power function equation:

$$Y = AX^B$$

Y = Unit Cost

A = A Constant

X = Annual Production Rate

B = A Coefficient which describes the slope of the rate/cost curve

This is the same equation as the familiar "experience curve" which is used extensively in the analysis of labor hours. A useful property of this equation is that it can be represented as a straight line on log-log graph paper, which simplifies graphic estimates and illustrations. Also, extensive tables are available[4] for the various slopes of this "experience curve" which simplify manual calculations.

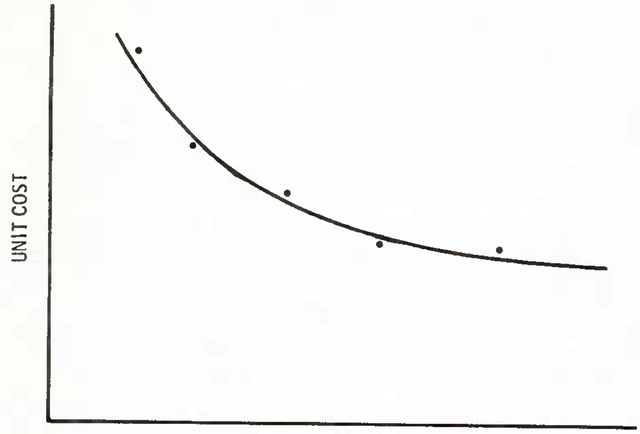

Figure 1. Least Squares Curve Fitted To Rate/Cost Data

There are a number of production rate options which can be used to produce the required number of units. The question of how fast initial production should be accelerated is a function not only of funding restraints, but of the technical risk of building substantial numbers of newly developed items before the design can fully mature. This risk involves the probability of incurring costly retrofits to early production units. At the upper boundary of production rate is the limitation of available plant capacity and the requirement for additional investments in tooling and facilities. Low rate production would be bounded by extreme costs and the fact that the program should not be stretched to the point that the product becomes technologically obsolete. These rate/time boundaries are shown in figure 2.

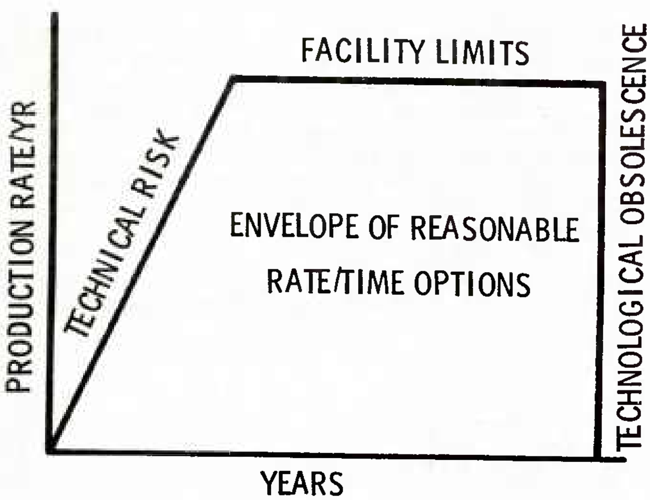

Figure 2. Envelope Of Rate/Time Options

Program costs for the different production rate options are calculated by summing the totals of the unit costs derived from the least squares line, multiplied by the number of units to be produced during the individual years. Program costs for the different production rate options are then compared. Additional questions which may be explored are shown in the example which follows.

AN EXAMPLE

Establishing a Trend Line

Since aircraft represent systems with high unit costs and relatively low production rates, an aircraft example is used to illustrate the method for estimating production rate/cost relationships.

In order to establish a trend line for the rate/cost relationships, twenty data points were identified from actual and projected aircraft programs. This data was normalized into percentages. Since the data represented several types of aircraft, and originated from several different contractors, the high degree of correlation for this set of hetrogeneous data (correlation coefficient 0.94) was surprising. The resulting trend line is shown as figure 3. Figure 4 depicts the same data as does the trend line, but is expressed in terms of the estimated percentage increase or decrease in unit cost that would result from a change in production rate.

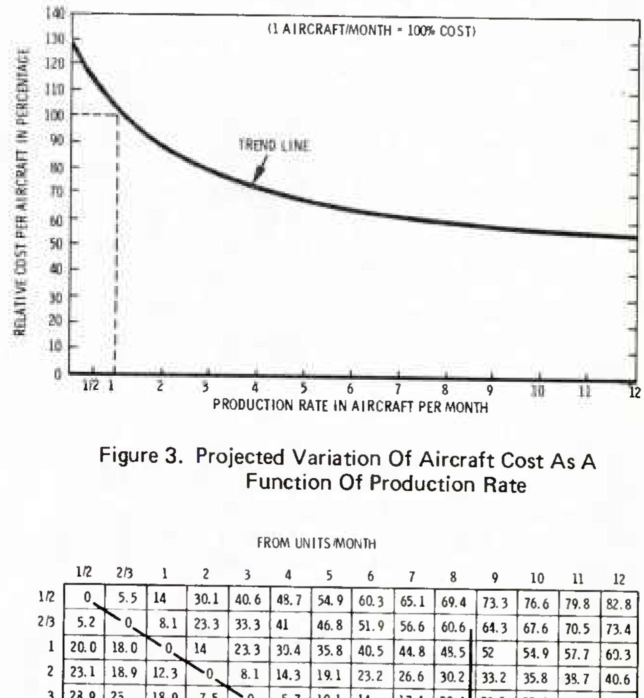

Figure 3. Projected Variation Of Aircraft Cost As A Function Of Production Rate

FROM UNITS/MONTH

TO UNITS/MONTH	1/2	2/3	1	2	3	4	5	6	7	8	9	10	11	12
1/2	0	5.5	14	30.1	40.6	48.7	54.9	60.3	65.1	69.4	73.3	76.6	79.8	82.8
2/3	5.2	0	8.1	23.3	33.3	41	46.8	51.9	56.6	60.6	64.3	67.6	70.5	73.4
1	20.0	18.0	0	14	23.3	30.4	35.8	40.5	44.8	48.5	52	54.9	57.7	60.3
2	23.1	18.9	12.3	0	8.1	14.3	19.1	23.2	26.6	30.2	33.2	35.8	38.7	40.6
3	28.9	25	18.9	7.5	0	5.7	10.1	14	17.4	20.4	23.2	25.6	27.8	30.0
4	32.7	29.1	23.3	12.5	5.4	0	4.2	7.8	11.0	13.9	16.5	18.8	20.9	23.0
5	35.4	31.9	26.4	16	9.2	4.0	0	3.5	6.6	9.4	11.9	14.0	16.1	18.1
6	37.6	34.2	28.8	18.8	12.2	7.2	3.4	0	3.0	5.7	8.1	10.2	12.2	14.1
7	39.4	36.1	30.9	21.2	14.8	9.9	6.2	2.9	0	2.5	4.9	6.9	8.9	10.7
8	41	37.7	32.7	23.2	17	12.2	8.6	5.4	2.5	0	2.3	4.3	6.2	8.0
9	42.3	39.1	34.2	24.9	18.8	14.2	10.6	7.5	4.7	2.3	0	1.9	3.8	5.5
10	43.4	40.3	35.4	26.4	20.4	15.8	12.3	9.3	6.5	4.1	1.9	0	1.8	3.5
11	44.4	41.3	36.6	27.7	21.9	17.3	13.9	10.9	8.2	5.8	3.6	1.8	0	1.7
12	45.3	42.3	37.6	28.9	23.1	18.7	15.3	12.3	9.7	7.4	5.2	3.4	1.6	0

Figure 4. Estimated Changes In Cost With Change Of Production Rate (Table Entries In Percent)

The Rate/Cost Model

From this data was derived a generalized model which would facilitate movement up and down the rate/cost trend line

$$\text{New Unit Cost} = \text{Present Unit Cost} \times \left(\frac{\text{New Rate}}{\text{Present Rate}}\right)^{-0.19}$$

The coefficient (-0.19) represents a slope of approximately 87.7 percent for the rate/cost curve. (This coefficient has been found to vary considerably from system to system).

The Case of the "Fifteen Million Dollar Airplane"

In order to illustrate the effect of production rate on production cost, a hypothetical program called the "Fifteen Million Dollar Airplane" will be used. Since inflation effects mask the production rate variable, all calculations are in constant dollars.

This program is described as follows:

- The unit cost of the airplane is 15 million dollars when it is in steady state production at a planned rate of 48 aircraft per year.
- Program requirements call for 500 aircraft.
- The production program is valued at \$15M X 500 = \$7.5 Billion

Six different production rate options are explored, each of which will result in the production of the required 500 aircraft. A slow build up of production rate was provided in order to minimize the risk of retrofit. The following questions will be explored for the different production rate options:

- How much do \$15M airplanes actually cost?
- What is the production program cost for 500 airplanes?
- How many \$15M airplanes can be produced for \$7.5B?
- What is the cost impact of a program stretch-out?
- What is the cost of providing a "warm production base?"
- What would be the effect of incremental program funding changes?

Figure 5 shows the number of aircraft produced each year for the six different production rate options, and the resulting unit cost for the aircraft. The unit costs were calculated using the rate/cost model discussed above. Note that the unit cost for the aircraft is \$15M only when it is being produced at the planned rate of 48 aircraft per year. The duration of the production programs necessary to produce the 500 aircraft vary from 8 years to 22 years, depending upon the production rates involved. In order to determine the funding requirement for any given year, the number of aircraft produced is multiplied by the unit cost. From these answers, the funding profile for the program can be determined. In order to determine the average cost of the aircraft for each production rate option, the total program cost is divided by 500, which was the total number of aircraft produced.

PRODUCTION RATE OPTIONS / YEARS

PLANNED RATE/YR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16→22	
108	6/22.3	12/19.5	36/15.8	72/13.9	108/12.9	108/12.9	108/12.9	50/14.9	—	—	—	—	—	—	—	—	—
72	6/22.3	12/19.5	24/17.1	48/15.0	72/13.9	72/13.9	72/13.9	72/13.9	72/13.9	50/14.9	—	—	—	—	—	—	—
60	6/22.3	12/19.5	24/17.1	36/15.8	48/15.0	60/14.4	60/14.4	60/14.4	60/14.4	60/14.4	60/14.4	14/19.0	—	—	—	—	—
48	6/22.3	12/19.5	24/17.1	36/15.8	48/15.0	48/15.0	48/15.0	48/15.0	48/15.0	48/15.0	48/15.0	48/15.0	38/15.7	—	—	—	—
36	6/22.3	12/19.5	24/17.1	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	36/15.8	26/16.9	—
24	6/22.3	12/19.5	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	24/17.1	26/16.9

Figure 5. Annual Production Rates And Unit Costs (\$M) For "\$15M Dollar Airplane"

PLANNED RATE PER YEAR	AVERAGE UNIT COST (\$M)
108	13.7
72	14.5
60	15.0
48	15.4
36	16.1
24	17.2

Thus, the results indicate a difference in average unit cost for the aircraft of \$3.5M between the highest and lowest production rate option.

Variation in Program Costs

Summing the required funding for each year for each different production rate option yielded the following values for total production program cost:

PLANNED RATE PER YEAR	PRODUCTION PROGRAM COST (\$M)
108	6848.34
72	7242.34
60	7510.10
48	7704.73
36	8060.76
24	8608.86

This data indicates a difference of \$1.7B in total program cost between the two extremes of production rates, or a 23.5 percent variation when compared to the \$7.5B production program value.

Variation in Number of Aircraft

In the program cost analysis the number of airplanes was held constant at 500, and the variation in funding requirements were examined. To explore the other side of this question, the number of dollars was held constant, and the number of resulting aircraft for each different production rate option was calculated. The results were as follows:

PLANNED RATE PER YEAR	NUMBER OF AIRPLANES FOR $7.5B
108	542
72	513
60	499
48	485
36	465
24	433

The 109 aircraft difference between the two extreme production rate options is very close to the projected total number of aircraft being procured by the Navy for fiscal year 1981. Could it be that there are some "free" airplanes to be realized in production rate planning and funding?

Effects of a Program Stretch-Out

In order to illustrate the cost of a program stretch-out, the following circumstances were assumed:

- 250 aircraft have been produced
- 250 aircraft are yet to be produced
- Present unit cost $15M
- Present production rate 48/yr
- New production rate 24/yr

From the rate/cost model

$$\text{New Unit Cost} = \text{Present Unit Cost} \times \left(\frac{\text{New Rate}}{\text{Present Rate}}\right)^{-0.19}$$

is obtained

$$\text{New Unit Cost} = \$15M \times \left(\frac{24}{48}\right)^{-0.19} = \$17.1M$$

thus

$$\text{Cost Increase} = (17.1 - 15)\ 250 = \underline{\$527.9M}$$

It would appear that a program stretch-out could be the start of a "vicious circle". A lack of funding could cause a program stretch-out, which reduces the production rate, which raises the unit cost, which causes a shortage of funding, etc.

The Cost of a "Warm Production Base"

Sometimes programs use a low rate of production in order to support the maintenance of a "warm production base" so that this base would be available in case of emergency. Data generated in a production rate/cost analysis can be helpful in estimating the cost of maintaining this base.

As an example, assume that the production rate option with a planned rate of 24/year is chosen instead of the 48/year option in order to maintain the "warm production base" for a longer period of time. Results found for these two options were:

PLANNED RATE	PROGRAM COST	PROGRAM YEARS
24/yr	$ 8608.86M	22
48/yr	$ 7704.73M	13

Then:

$$\Delta \text{ cost} = \$904.13M$$

$$\Delta \text{ years} = 9$$

$$\text{Annual cost} = \frac{\$904.13M}{9} = \underline{\$100.5M}$$

The Effects of Incremental Funding Changes

During the annual budget planning cycle frequent "what if" questions arise concerning the funding levels for a system.

These "what if" questions were applied to the funding for the "15 Million Dollar Airplane" program, and the results are shown in figure 6. These results indicate that as funding is cut and fewer units can be procured, the effect is to decrease annual production rate, and thus increase unit cost. The opposite effect is noted as increments of funding are added to the program. The result is a disproportionate adjustment in the number of units procured. For example, a 30 percent cut in funding would reduce the number of units funded by 35.6 percent and change the unit cost from $15M to $16.3M. On the other hand, a 30 percent increase in funding would increase the number of units funded by 38.3 percent and decrease the unit cost from $15M to $14.1M.

PERCENT CHANGE IN FUNDING	PERCENT CHANGE IN UNITS FUNDED	FUNDING LEVEL ($M)	UNITS FUNDED	UNIT COST ($M)
+50%	+65.0%	1080	79.2	13.6
+40%	+51.5%	1008	72.7	13.9
+30%	+38.3%	936	66.4	14.1
+20%	+25.2%	864	60.1	14.4
+10%	+12.5%	792	54.0	14.7
0	0	720	48	15
-10%	-12.2%	648	42.1	15.4
-20%	-24.1%	576	36.4	15.8
-30%	-35.6%	504	30.9	16.3
-40%	-46.8%	432	25.5	16.9
-50%	-57.5%	360	20.4	17.7

Figure 6. Effects Of Incremental Funding Changes

ACKNOWLEDGEMENT

I wish to thank Mr. Lee Schumacher of the DoD Product Engineering Services Office for writing the computer program which is contained in Appendix A.

REFERENCES

1. House of Representatives Report No. 95-1573, "Department of Defense Appropriation Authorization Act, 1979"

2. General Accounting Office Report PSAD-80-6, "Impediments to Reducing the Costs of Weapon Systems," November 1979

3. DoD Instruction 5000.2, "Major System Acquisition Procedures," (Draft), October 1979

4. Army Missile Command, Redstone Arsenal, Alabama, "The Experience Curves," Vols. I & II, 1964, AD 612 803

APPENDIX A

Computer Analysis

In order to perform the production rate/cost calculations readily, a computer program has been devised. This program is written in BASIC language. To use this program it is necessary to have determined the exponent "B" for the rate/cost curve in the form

$$Y = AX^{B}$$

The Inputs

The program is interactive in that it asks the user for specific data necessary to perform the rate/cost calculations. The inputs to the program are:

- A unit cost for a specific rate
- The annual production rate associated with this cost
- The exponent "B" of the rate/cost curve
- The number of years for the production rate option being analyzed
- The production rate for each year of the rate option

The Outputs (Example)

UNIT COST	QUANTITY	YEARLY COST
22.2679	6	133.607
19.5201	12	234.242
15.8427	36	570.338
13.8878	72	999.923
12.8581	108	1388.67
12.8581	108	1388.67
12.8581	108	1388.67
14.8841	50	744.205
---------	--------	-----------
13.6967	500	6248.34

After the inputs are made the computer performs the necessary calculations and presents the results in the form of a table containing the following information:

- Number of units produced each year
- Unit costs for each year
- Total costs for each year
- Average unit cost for the production rate option
- Total number of units produced
- Total program cost for the rate option

The Program

The listing of the computer program steps is:

```
100 DIM Q(25)
110 PRINT
120 PRINT 'UNIT COST'
130 PRINT
140 INPUT U
150 PRINT'RATE'
160 PRINT
170 INPUT R
180 PRINT 'EXPONENT(POSITIVE)'
190 PRINT
200 INPUT E
210 E=-E
220 PRINT
230 PRINT
240 PRINT 'NO. OF YEARS (0 TO EXIT)'
250 PRINT
260 INPUT Y
270 IF Y=0 THEN 530
280 FOR I=1 TO Y
290 PRINT 'RATE FOR YEAR',I
300 PRINT
310 INPUT Q(I)
320 NEXT I
330 K=0 .
340 PRINT
350 PRINT 'UNIT COST','QUANTITY','YEARLY COST'
360 W=0
370 FOR I=1 TO Y
380 C=((Q(I)/R)^E)*U
390 T=C*Q(I)
400 PRINT C,Q(I),T
410 W=W+Q(I)
420 K=K+T
430 NEXT I
445 PRINT '---------','--------','-----------'
450 Y=K/W
470 PRINT Y,W,K
480 PRINT
490 PRINT
500 GOTO 240
510 PRINT
520 PRINT
530 STOP
```

SOME ACQUISITION STRATEGY IMPLICATIONS DRAWN FROM A THEORETICAL EXAMINATION OF THE FRONT END OF THE PROCESS

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ABSTRACT

This paper presents a theoretical description of an extremely simplified example of the acquisition of a new ASW system. Using this simplified example, the paper outlines how implications and conclusions may be drawn from a quantitative theoretical model that can be helpful to the acquisition manager in formulating acquisition strategy in the real world.

PURPOSE

The purpose of this paper is to demonstrate that the use of a quantified decision model based upon a single-valued decision criterion can facilitate the formulation of acquisition strategy.

THE CRITERION

Reference (1) suggests that every decision-maker, in the final analysis, must use a criterion which provides a common single-valued basis for directly comparing the alternatives. Otherwise, he cannot rationally rank one alternative relative to another. In Appendix A this single-valued criterion has been defined as "Net Military Gain." Net Military Gain (NMG) is given by the equation:

$$NMG = MW-LCC$$

where:

MW = Military Worth (Military effectiveness expressed in dollars)

LCC = Life Cycle Cost.

AN IDEALIZED CASE

Appendix A describes a quantitative theoretical model (i.e., an equation which applies the use of Net Military Gain in the selection process) for acquiring a new inventory of Anti-Submarine Warfare (ASW) systems. The example assumes that there are 20 alternate designs from which to choose.

Inasmuch as the purpose of the entire acquisition process is to select and produce the best weapon system design from those available, it is important at the beginning of a program to define how the final choice is to be made. The following discussion outlines how a Source Selection Authority can choose rationally from the 20 designs described in Appendix A.

Figure 1 shows a plot of the Military Worth and the Life Cycle Cost of all 20 designs. From Figure 1 it is clear that the "best" design can be chosen from one of the five (d122, d121, d112, d232, or d312) which define the upper left boundary of all of the designs shown. All other designs represent higher cost, less effective choices. In order for the Source Selection Authority to choose the best design from the above five, he must decide (implicity or explicitly) the relative advantage of a marginal increase in effectiveness in comparison to a marginal increase in the cost that must be expended to achieve the particular increase. In Appendix A it has been assumed that the increases in effectiveness and reductions in cost are of equal value. With this assumption, lines of constant Net Military Gain can be drawn as shown on Figure 1. Also, it can be determined that design d232 is the best design, with a Net Military Gain of 2.90, compared to a value of 2.74 for the nearest competitor (design d312).

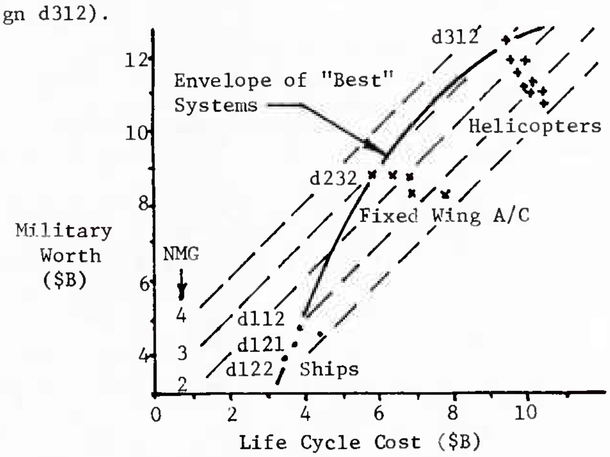

Figure 1. Cost-Worth of 20 ASW Systems (NMG = MW-LCC)

It is believed obvious that if a different relationship is assumed between effectiveness and cost, a different "best" design may be the result. As an example, the effect of a different assumption is shown on Figure 2. In this figure it is assumed that Net Military Gain = 1.25 x ME-LCC. With this assumption, the best design on Figure 2 becomes design d321, with a Net Military Gain of 5.865.

The decision model as outlined in Appendix A may be considered as a three-tiered hierarchy as shown on Table 1. Net Military Gain is defined as a function of Military Worth and Life Cycle Cost as has

been discussed. At the next lower tier, Military Worth is defined as a function of range, speed, and payload; and Life Cycle Cost is defined as a function of system weight (in a real world example, Life Cycle Cost is more logically estimated as a function of development, production, and operating and support costs).

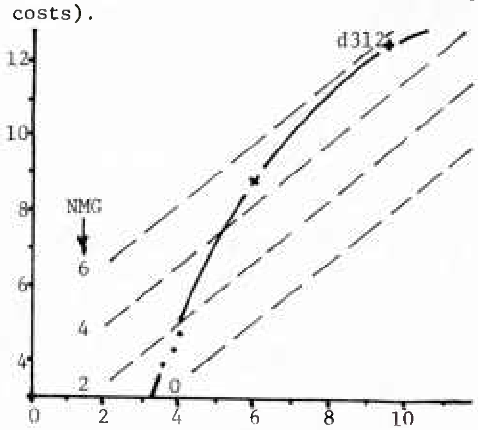

Figure 2. Cost-Worth of 20 ASW Systems (NMG = 1.25 MW-LCC)

1	Net Military Gain			
2	Military Worth			Life Cycle Cost
3	Range	Speed	Payload	Weight

Table 1. Decision Model Hierarchy

The model in Appendix A makes further assumptions relative to the relationship of the variables in the third tier to those in the second tier. These relationships for each of the three system concepts are given in Table 2. Each of the variables in the third tier in Table 2:

- Has a different impact on the final selection criterion (Net Military Gain)
- Has a different probability of being the true value that will be achieved in the production weapon system.

SENSITIVITY ANALYSIS

The use of single-valued decision criterion (e.g., Net Military Gain) allows a sensitivity analysis in which the effect of a change to any of these important variables can be compared on a common basis. In other words, the effect of change can be viewed in the single value for Net Military Gain. Knowing the relative importance of achieving the target value of these variables (as the result of a sensitivity analysis) will help guide the manager as to which variables warrant the applications of his scarce personal time and resources throughout the life of the acquisition.

Many development contracts include provisions for financial incentives. These incentives are usually tied to performance variables such as those shown in Table 2. The intent of these incentives is to focus the organization of the contractor on objectives consistent with those of the acquisition manager. A quantitative sensitivity analysis, like the one discussed above, can serve two important functions. One function is to establish the relative rankings of design variables (i.e., which ones ultimately affect the decision criterion (e.g., Net Military Gain). A second function is to help establish levels and types of incentives associated with meeting target values for the design variables.

Thus, a sensitivity analysis, as discussed above assists the acquisition manager in:

- Making the trade-offs which must be made in all programs when problems arise (financial and/or technical) that force compromises in achieving one or more of the key variables (such as those listed in Table 2).
- Providing guidance in allocating resources to validate achievement of the target values of the key variables.
- Quantifying development contract incentives.

THE NUMBERS OF BIDDERS

Another aspect of developing acquisition strategy is that of determining the number of bidders who should be solicited at various life cycle phases of the acquisition. Appendix B presents an elementary

SYSTEM CONCEPT	EQUATIONS
Ship Systems	Military Worth = $\frac{\text{Range}}{1000} + \frac{\text{Speed}}{100} + \frac{\text{Payload}}{300,000}$ Life Cycle Cost = 10,000 x Weight
Land Based, Fixed Wing Aircraft Systems	Military Worth = $\frac{\text{Range}}{1000} + \frac{\text{Speed}}{100} + \frac{\text{Payload}}{5,000}$ Life Cycle Cost = 100,000 Weight
Carrier Based, Helicopter Systems	Military Worth = $\frac{\text{Range}}{100} + \frac{\text{Speed}}{20} + \frac{\text{Payload}}{500}$ Life Cycle Cost = 120,000 x Weithg + 7.0

Table 2. Military Worth and Life Cycle Cost Equations

equation of the expected Net Military Gain which will accrue to the decision-maker considering the number of bidders and the probability that each will propose a weapon system design that will provide a Net Military Gain greater than would be available with an existing system. For the purposes of this discussion a bidder who has no probability of proposing a technically feasible design that will provide a Net Military Gain greater than zero (because of inadequate resources, technical, or management capabilities, for example) is defined as an unqualified bidder. A bidder who has some probability of proposing a technically feasible design that will provide a Net Military Gain greater than zero is defined as a qualified bidder. Also, a system design which provides a Net Military gain equal to an existing operational system is defined as providing a Net Military Gain of zero.

By examining the equation in Appendix B it can be concluded that:

- The greater the number of qualified designs (and therefore, the greater the number of qualified bidders solicited) the greater is the expected Net Military Gain to the decision-maker.
- Considering unqualified designs (and unqualified bidders) can make no contribution to expected Net Military Gain.

THE REAL WORLD

There are a large number of factors in the real world which prevent use of a quantitative model which approaches the preciseness of the examples discussed above.

The decisions which must be made by the acquisition manager during the process have the objective of providing the best weapon system at some future date. Early in the process (pre-Milestone 0) the service introduction date of the system may be 7 to 10 years in the future. Following service introduction, the system may have a service life (the period over which life cycle costs are desired to cover) that may exceed an additional 20 years. Although the theoretical objective of the acquisition manager is to provide the most cost-effective weapon system, the futurity of the process prevents knowing what either the military effectiveness (or worth) and/or the life cycle cost of the system will ultimately be.

It is recognized that predicting the future, particularly predicting it in detail, is not possible. However, despite the limitations in making such predictions, it is the recommendation of this paper that explicit quantitative estimates should be made as early in a program as is practical. These estimates will have broad tolerances on their accuracy early in the program and should become more precise as more information is obtained and validated as the process proceeds.

First consider the "top tier" criterion for comparing the relative merit of alternate weapon system designs. Formal government documents recognize that the essential characteristics in comparing weapon systems are: estimated military effectiveness, estimated life cycle cost, and the risk associated with each of these characteristics (2). However, there is no guidance as to the relative importance of each of these characteristics (nor should there be in any general instruction).

It is suggested that although a relationship between effectiveness, cost and the risk associated with each may not be explicitly defined in the Source Selection choice, any choice of the "best" system results from an implicit assumption as to some relationship. This is true whether the relationsihp is known to parties other than the decision-maker (Source Selection Authority) or not (in fact, the explicit relationship may not be known to the decision-maker, himself). It is the recommendation of this paper that the criterion used in the key choices that are made throughout the acquisition process should be explicit and recorded in as many cases as is practical. With a record of both the assumptions and the decision criteria used throughout the process, actual results achieved downstream may be checked against the assumptions and criteria and desirable revisions made where indicated. It is suggested that the recommended procedure results in the following benefits:

- Maximizes institutional learning by providing a formal feedback mechanism for comparing assumptions with results.
- Provides a basis for comparing alternate concepts relatively independent of hardware designs (as required by OMB Circular A-109).
- Provides consistent acquisition objectives throughout the process despite changes in the Project Manager and/or other key personnel.

There are many sophisticated methodologies (including complex computer programs) for calculating the performance values used in estimating military effectiveness and life cycle cost. Also, methodologies are being developed for estimating risk or uncertainty (3). However, unless the detailed lower tier models are integrated into a top tier decision model, the lower level models have a high probability of being either incomplete or redundant. It would appear clear that the decisions made in the acquisition process can be no better than the decision model (explicit or implicit) used in making the decision.

Next consider estimating life cycle cost. As has been discussed, because we are dealing with the future, it is a practical impossibility to predict accurate absolute values of life cycle cost. Fortunately, the need of the acquisition manager is primarily one of predicting the relative values of costs. Choosing the best alternative from those available only requires estimates of the future capabilities and costs of each of the alternative designs relative to its competitor. Life cycle cost estimates can contribute greatly to making relative comparisons a rational decision process.

Next consider estimating risk. Estimating risk far into the future is no less difficult than estimating effectiveness and cost. Yet every rational acquisition manager must identify "high" risk areas

in his project and give these areas special attention. Quantifying these estimates has the same advantages as previously outlined for other aspects of an acquisition.

In the large complex organizations required for the management of major acquisitions it is suggested that an explicit decision model will:

- Generate healthy discussions between the key personnel (each representing major elements of the program that must be considered and integrated) who have legitimate different interests and responsibilities. Reconciling these differences "openly" early in the program will produce the best practical decision model. This model, in turn, will then promote integrated objectives at all levels of the organization.
- Establish a basis for formulating the acquisition strategy for collecting the information needed to make the choices that must be made throughout the acquisition process.
- Clarify the kinds of skills that should be employed to obtain the needed information (systems analysts for preparing military scenarios, preliminary designers for evaluating designs, as examples).

Because of the length of the acquisition process and the limited tours of military managers it is not practical for acquisition managers to get any significant amount of on-the-job training. In addition, new directives, such as OMB Circular A-109, periodically impose new formal procedures. Thus, managers are required to implement new techniques where management experience has not been recorded and formalized into a body of knowledge that can be readily taught. It is suggested that the development of quantitative theoretical descriptions of the acquisition process greatly facilitates, not only this needed teachability, but also enhances the improvement of the process itself.

Many of the implications and conclusions outlined are "obvious" to the experienced acquisition manager. However, a valid theoretical model enables the inexperienced manager to derive these implications and conclusions from the model without instructions from (scarce) experienced managers.

SUMMARY

In summary, this paper suggests that the development of an acquisition strategy early in the process can be facilitated by:

- Recognizing that the acquisition process is fundamentally a decision process that requires the collection and structuring of information necessary for making choices.
- Structuring a "top tier" decision model as a basis for integrating objectives at all levels of the entire project as a first priority task.
- Formally quantifying the assumptions and decision criteria used throughout the process which can be checked against actual results obtained downstream in the project.

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APPENDIX A. A SIMPLIFIED AND IDEALIZED DECISION MODEL FOR SELECTING THE BEST ASW SYSTEM DESIGN

The purpose of this example is to illustrate how a single-valued criterion (defined as Net Military Gain) may be used to make a rational selection of the "best" weapon system design. The idealized example assumes that complete and true (accurate) information is available to the decision maker. The following additional assumptions are:

- There is a requirement for an inventory of new ASW weapon systems.
- There exists an exclusive and exhaustive set of twenty alternative weapon system designs which will produce an increase in Net Military Gain.
- The twenty weapon system designs are all within program constraints (schedule, cost, and other available resources) and are technically feasible.

These twenty weapon system designs are subsets of nine weapon system design concepts which are, in turn, subsets of three weapon system concepts. (Table I lists this assumed arrangement with a brief description of each weapon system concept and each weapon system design concept).

The values of the variables which affect the military net gain of each weapon system design, the decision model (equations) for determining the net military gain and the calculated value of the net military gain for each design are as shown on Tables II, III, and IV.

Table V shows some results which may be calculated from the net military gain values of each design listed on Tables II, III, and IV.

The results of the calculations of the probable (or expected) Net Military Gain are shown on Table V. It can be seen from Table V that design d232 with a probable Net Military Gain of 2.90 is the best system.

APPENDIX B. EQUATION FOR QUANTIFYING THE RELATIONSHIP BETWEEN THE NUMBER OF DESIGNS AND THE EXPECTED NET MILITARY GAIN

The Military Net Gain that is expected to result to decision maker is given by the equation:

$$P_G G = \frac{\Sigma(P_1G_1 + P_2G_2 + \ldots P_nG_n)}{N}$$

where:

G = The value of Net Military Gain available to the decision-maker.

P_G = The probability that a design which provides a Net Military Gain with a value of G will be chosen.

G_1, G_2, G_n = The values of Military Net Gain that will be provided by designs 1, 2, and n, respectively.

P_1, P_2, P_n = The probability that designs 1, 3, and n, respectfully; will be chosen

n = The total number of designs available that will provide a value of Net Military Gain greater than zero.

A design which provides a Net Military Gain equal to an existing system is defined as providing a Net Military Gain of zero.

TABLE I. EXHAUSTIVE AND EXCLUSIVE SET OF CHOICES

THREE CONCEPTS		NINE DESIGN CONCEPTS		TWENTY DESIGNS
Identification	Description	Identification	Description	
(c1)	Ships	(dc11)	Diesel Power Ships	Design d111 Design d112
		(dc12)	Turbine Powered Ships	Design d121 Design d122
(c2)	Land Based, Fix Wing Aircraft	(dc21)	Turbojet Powered Aircraft	Design d211 Design d212
		(dc22)	Low Bypass Turbofan Powered Aircraft	Design d221 Design d222
		(dc23)	High Bypass Turbofan Powered Aircraft	Design d231 Design d232
(c3)	Carrier Based Helicopters	(dc31)	Single Rotor Helicopters	Design d311 Design d312
		(dc32)	Single Rotor Helicopters with Turbojets	Design d321 Design d322 Design d323
		(dc33)	Dual Rotor Helicopters	Design d331 Design d332
		(dc34)	Dual Rotor Helicopters with Turbojets	Design d341 Design d342 Design d343

TABLE II. CHARACTERISTICS AND DECISION MODEL
(C1) SHIP SYSTEM CONCEPT

Weapon System Design Concept	Design Identification	Range (n.mi)	Speed (knots)	Payload (lbs.)	Weight (lbs.)	Military Worth ($B)	Life Cycle Cost ($B)	Net Military Gain ($B)
(dc11) Diesel Powered	d111	4,000	26	130,000	450,000	4.69	4.5	0.19
	d112	4,200	24	130,000	400,000	4.87	4.0	0.87
(dc12) Turbine Powered	d121	3,500	28	150,000	380,000	4.28	3.8	0.48
	d122	3,200	32	140,000	350,000	3.99	3.5	0.49

(Continued)

TABLE II (Continued)

$$\text{Military Worth} = \frac{\text{Range}}{1000} + \frac{\text{Speed}}{100} + \frac{\text{Payload}}{300{,}000}$$

Life Cycle Cost = 10,000 X Weight

Net Military Gain = Military Worth - Life Cycle Cost

TABLE III. CHARACTERISTICS AND DECISION MODEL
(C2) LAND BASED, FIXED WING AIRCRAFT SYSTEM CONCEPT

Weapon Systems Design Concept	Design Identification	Range (n.mi.)	Speed (knots)	Payload (lbs.)	Weight (lbs.)	Military Worth ($B)	Life Cycle Cost ($B)	Net Military Gain ($B)
(dc21) Turbojet Powered Aircraft	d211	1,500	550	7,000	80,000	8.4	8.0	0.40
	d212	1,600	520	8,000	70,000	8.4	7.0	1.40
(dc22) Low Bypass Turbofan Powered A/C	d221	1,800	500	10,000	70,000	8.8	7.0	1.80
	d222	1,900	500	10,000	65,000	8.9	6.5	2.40
(dc23) High Bypass Turbofan Powered A/C	d231	2,400	450	10,000	65,000	8.9	6.5	2.40
	d232	2,500	420	11,000	60,000	8.9	6.0	2.90

$$\text{Military Worth} = \frac{\text{Range}}{1000} + \frac{\text{Speed}}{100} + \frac{\text{Payload}}{5{,}000}$$

Life Cycle Cost + 100,000 X Weight

Net Military Gain = Military Worth - Life Cycle Cost

TABLE IV. CHARACTERISTICS AND DECISION MODEL
(C3) CARRIER BASED, HELICOPTER SYSTEM CONCEPT

Weapon Systems Design Concept	Design Identification	Range (n.mi.)	Speed (knots)	Payload (lbs.)	Weight (lbs.)	Military Worth ($B)	Life Cycle Cost ($B)	Net Military Gain ($B)
(dc31) Single Rotor Helicopters	d311	250	90	2,500	23,000	12.0	9.76	2.24
	d312	220	110	2,400	23,000	12.5	9.76	2.74
(dc32) Single Rotor Helicopter with Turbojets	d321	120	150	1,200	30,000	11.1	10.60	0.50
	d322	120	160	1,100	28,000	11.4	10.36	1.04
	d323	100	180	1,000	26,000	12.0	10.12	1.88
(dc33) Dual Rotor Helicopters	d331	220	90	2,500	25,000	11.7	10.00	1.70
	d332	210	100	2,400	24,000	11.9	9.88	2.02
(dc34) Dual Rotor Helicopter with Turbojets	d341	110	150	1,100	30,000	10.8	10.60	0.20
	d342	100	160	1,000	28,000	11.0	10.36	0.64
	d343	90	170	900	26,000	11.2	10.12	1.08

$$\text{Military Worth} = \frac{\text{Range}}{100} + \frac{\text{Speed}}{20} + \frac{\text{Payload}}{500}$$

Life Cycle Cost = 120,000 X Weight + 7.0

Net Military Gain = Military Worth - Life Cycle Cost

TABLE V. PROBABLE NET MILITARY GAIN AFTER THE CHOICE OF VARIOUS ALTERNATIVES

System Concept Chosen	Probable Net Military Gains Produced ($B)	System Design Concept Chosen ($B)	Probable Net Military Gain Produced ($B)	Design Chosen	Probable* Net Military Gain Produced ($B)
(c1) Ships	0.5075	(dc11) Diesel Powered Ships	0.530	d111 d112	0.19 0.87
		(dc12) Turbine Powered Ships	0.485	d121 d122	0.48 0.49
(c2) Land Based Fixed Wing Aircraft	1.8833	(dc21) Turbojet Powered Aircraft	0.900	d211 d212	0.40 1.40
		(dc22) Low Bypass Turbo-fan Powered Air-craft	2.100	d221 d222	1.80 2.40
		(dc23) High Bypass Turbo-fan Powered Air-craft	2.650	d231 d232	2.40 2.90
(c3) Carrier Based Helicopters	1.5325	(dc31) Single Rotor Helicopters	2.490	d311 d312	2.24 2.74
		(dc32) Single Rotor Helicopter with Turbojets	1.140	d321 d322 d323	0.50 1.04 1.88
		(dc33) Dual Rotor Helicopters	1.860	d331 d332	1.70 2.02
		(dc34) Dual Rotor Helicopter with Turbojets	0.640	d341 d342 d343	0.20 0.64 1.08

*In this idealized example, with complete information, after the design is chosen the probability is 1.0 of producing the listed value of Net Military Gain.

THE PROGRAM PLANNING AND MANAGEMENT SYSTEM AND ITS USE IN THE MANAGEMENT OF A SPACE PROGRAM

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ABSTRACT

A successful acquisition program requires systematic, thorough, and continuing planning, followed by diligent management throughout the execution of the program. We have, over the past few years, developed and refined our contract management capabilities so that they are quite effective. Many of the problems which now surface in our contracts can be traced to inadequate early planning which resulted in an underscoped and optimistic program. This paper outlines the program planning activities of a major space system program office, and shows how a carefully designed computer supported management system strengthened that program office's planning process. A similar approach should have broad application for other Defense acquisition programs.

PROGRAM PLANNING & MANAGEMENT SYSTEM

We have focused a great deal of management attention, at all levels, on the problem of tracking and controlling contracts. We have given far less attention to the critical "front-end" management problems of planning system programs, projecting budgets which adequately account for program uncertainties, and making the decisions which lead to new contracts and to contract changes. The program management, financial management, and budgeting disciplines are intimately connected in these important early steps in this continually recurring cycle. The system program director's ability to successfully manage his program may be determined more by these early steps than by his subsequent management actions. The Program Planning and Management System (PPMS) was developed for use in direct support of the system program director's front-end decision making responsibilities. PPMS was designed for use in the Directorate for Advanced Technology of the Office of Special Projects, Office of the Secretary of the Air Force. The Directorate of Advanced Technology is a system program office (SPO) with responsibility for development and operation of several experimental space satellite programs involving multiple contractors and several government agencies. PPMS should be directly applicable to most development programs.

THE SPO MANAGEMENT PROCESS

The PPMS system is not a remedy for the lack of an adequate management process within the SPO. PPMS was, in fact, designed and implemented to strengthen the existing SPO management process and to make it more efficient. Because of its importance, I'll outline the planning process used in the Directorate for Advanced Technology before discussing how the PPMS fits into that process. PPMS is used for planning and budgeting the programs, in the allocation of work and budgets to the several program managers within the Advanced Technology SPO, and in aiding the program director in making his procurement decisions. The emphasis in this paper will be on the use of PPMS in the planning part of the process.

The Program Planning Process. The planning process used in this multi-program SPO is illustrated in Figure 1. Our program planning was based on several very fundamental principles which I will outline briefly:

> Planning a successful system program acquisition is a continuing process;
>
> Successful programs must be planned based on program alternatives which provide significantly different capabilities (true minimum, basic, and enhanced levels in the zero base budgeting (ZBB) terminology);
>
> Planning must involve everyone who has a role in the program: the SPO, the contractors, other Government agencies, and any Federal Contract Research Center support (like the Aerospace Corporation);
>
> The primary duty of the program manager is to make decisions.

I will explain our planning process using Figure 1 as a reference. The key people are the program manager, his program control chief (my duty at the time), and the comptroller. We begin with a review of the approved program, and an assessment of the mission requirements and the available technologies. Although we show the budget guidance as an input to that process, our activities were scheduled based on meeting budget delivery dates without waiting for the budget guidance; the approach we employed always enabled us to bound the budget guidance. The program manager and I would develop at least three alternative program plans; these would be assembled as a set of master schedules (program schedule, spacecraft schedule, ground station schedule, etc). I strongly believe that this must be done by the Government program

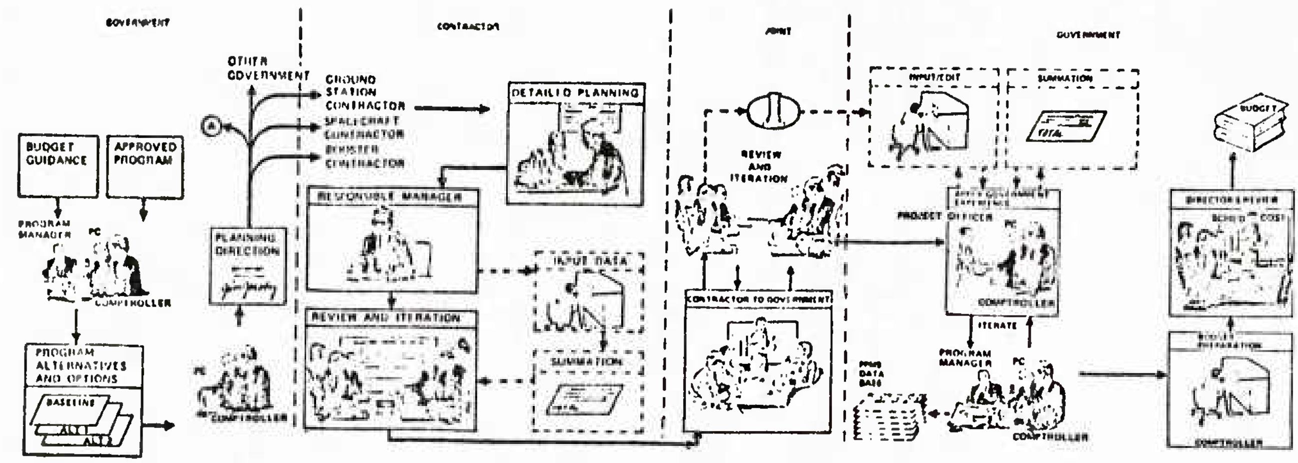

FIGURE 1. **PPMS IN THE MANAGEMENT PROCESS**

PROGRAM PLANNING

office and not by the contractors. These alternative plans were always program (not contract) oriented; doing so is a key factor to success because it encourages thinking on the broadest possible scale.

I will outline the distinction between our various program alternatives. This process was used even before zero base budgeting was implemented within the Federal Government, because the type of planning envisioned by ZBB and embodied in PPMS provides the program manager a far greater ability to understand and control the direction of his program.

Our Baseline program (approximately equivalent to today's ZBB approved level) is based on the concept of evolutionary improvement in mission capability, and would be targeted to provide--in the program manager's judgment--a balance between operational capability and acquisition and operating costs. In this particular case an increased number of spacecraft would be on orbit, the ground station would be expanded to handle the increased spacecraft control and payload data processing demands, selected capability improvements would be planned for both spacecraft and the ground station, and booster improvements would be projected when the spacecraft weight grows beyond the capability of the existing booster.

Our Alternative 1 program (today's ZBB minimum level) is targeted toward the lowest level of operationally useable capability that the basic satellite system design is capable of providing. This means that we would have the absolute minimum number of spacecraft on orbit, use the existing ground station without modification, make no capability upgrades, and limit system modifications to those necessary for reliability or mission assurance reasons. Spacecraft procurement schedules and operating funds are planned at the minimum level capable of meeting these limited capability objectives. Of course this means that we would have production breaks and the associated cost increases in individual spacecraft procurements, but it does provide the lowest total program cost.

Our Alternative 2 program (todays ZBB enhanced level) would generally contain all of the capabilities in the Baseline program, but at some point would phase into a block change spacecraft to provide a major increase in operational capability. Associated with the spacecraft block change is a major increase in the ground station capability to handle the new spacecraft and to convert from a batch processing to a real time processing system to increase both the timeliness and throughput of the processed data. The block change spacecraft (and the improved program capabilities that result) are keyed to a Space Shuttle launch after the Shuttle is operationally available.

As you can see, each of these program alternatives would result in a significantly different capability and significantly different acquisition and operating costs. Generally, the Baseline program would be at or very near the approved funding levels--particularly in the near term. Even the Alternative 2 (enhanced) program would be constrained in the near term to approved funding levels. Each of these program plans would be displayed in a reasonable level of detail in a master program schedule with any necessary subordinate schedules. In order to ensure that all the participants could clearly understand the major milestones and capabilities to be achieved, my office would assemble these alternative program plans into new planning direction which I would send to

each of the contractors and other Government agencies involved in the spacecraft program. That direction would transmit the program alternatives, set limits and constraints, and define the capability that we desire to have at each point in time. We would ask all the participants to prepare budgets for each of the major program alternatives.

Of course the most significant participants in this planning process are our major contractors. Because of the magnitude of their role, each contractor, upon receiving my planning direction, would prepare the more detailed plans needed to price each program alternative (e.g., schedules for the procurement of long lead material and assembly or test of the spacecraft systems). Then each responsible manager would review the program plans and price his own area of responsibility. These data are collected in a very carefully defined format which I will be discussing later. Once the responsible managers have completed their estimating, the contractor program manager reviews and iterates the work until he is satisfied with the final product. This is done for each alternative program plan included in my planning direction.

When contractor management is satisfied, then the next phase of activity would be conducted jointly between our SPO and the contractor. The contractor program manager and his senior staff present their assessment to our program manager and his senior staff. They discuss their recommendations, costing changes from previous submissions, and any other area of particular interest. We then jointly review and iterate the contractor product. After this is complete the data is formally delivered to the program office. This was done manually until PPMS was operational; then the entire contractor data base was delivered on a computer disc for direct input to our activities.

At this point, my program control staff leads the Government effort to evaluate the contractor submission and to adjust the cost estimates based on our own experience. Our project officers and our comptroller are active participants throughout this phase of the activity. Most of our effort was concentrated on making the contractor input complete and consistent, defining the cost of the program alternatives, and assembling and evaluating selected options. Once all this activity is complete, we conduct a detailed and thorough review with the program manager. This same process is performed for each of the several space programs within the SPO. Each of our program managers then provides his direction regarding program content, priority of options, changes to be made in the program to meet financial or schedule constraints, and any other direction he feels appropriate. My staff would iterate the analysis process with each program manager until we provided each one with a satisfactory set of program alternatives. This process was also performed with our Deputy Director (or system program director) so that each of our major programs would have several alternative plans in a thoroughly documented and approved data base which we would use for subsequent management activity.

At this point the final budget preparation process would begin; my staff would assist the comptroller in assembling the budget and presenting it to the Director for his review and approval. After the Director's comments are incorporated into the program plans, the formal budget is assembled and submitted for consideration in the Air Force budget process. This activity is essentially the same for both the Program Objective Memorandum (POM) and Budget Estimate Submission (BES) cycles.

I have deliberately limited my discussion of the PPMS role in this management process. PPMS activity is shown on Figure 1 in the dashed blocks; I will discuss the PPMS contribution later in this paper.

I have discussed our program planning process in some detail; program planning will be the overall emphasis of this paper, but PPMS supports the Deputy Director's responsibilities from these early planning steps through the allocation of work to his program managers and up until the final decision to procure any specific item. I'll discuss those last two tasks very briefly.

Allocation of Work and Budgets. Once the final program plans and budgets are prepared and submitted, the updated Baseline program (which by definition is the one currently being pursued) would become our basis for current year management decisions. Each of the major tasks and their associated budgets would be allocated to each program manager. All reserves are held by the Deputy Director for use as required in making his future decisions.

Procurement Decisions. The Deputy Director's procurement decisions are the final step in the sequence of events which began with defining each of the individual decision packages at the beginning of the planning process. This decision making continues throughout the program and it is, in fact, very similar whether it involves a new contract for a new satellite system, or engineering changes to existing development or operational contracts. The Deputy Director receives a detailed requirements and technical analysis on every procurement action from the responsible technical manager. My staff would provide a financial evaluation which includes an assessment of the impact on the Director's reserves and on his future decision making capability. This is one function which we could not credibly perform before PPMS was operational. The Deputy Director's procurement decision is the end of the chain of events which the PPMS is designed to support. From that point forward, the contract tracking, reporting, and management actions are handled in a manner similar to that done in other program offices.

PPMS DESCRIPTION

I have discussed the management process that we employed in the Directorate for Advanced Technology SPO; now I'll outline the program planning and management system (PPMS) concept, discuss some key elements of PPMS, and show how it fits into our

management process.

PPMS Concept. The PPMS concept is built upon the premise that the primary duty of a system program director (SPD) is to make decisions. PPMS is designed to provide the proper mix and granularity of programmatic, technical, cost, and schedule information for SPD decision making. I believe that the computer should support the decision process, but that the computer should make no decisions. Further, within the Directorate for Advanced Technology, we believed that, in spite of the R&D nature of our work, the budget should represent the equivalent of a fixed price contract between the SPO and top management (Air Force, OSD and Congressional). I also believe that the most serious impediment to achieving an adequate budget is the failure to identify all of the work required to actually deliver an operational capability; put in simpler terms, "completeness" is the most important criterion in planning programs and establishing budgets. By systematically identifying all of the work required we are able to focus our attention on the areas of greatest uncertainty and spend most of our effort there in analyzing and projecting the ultimate cost of the program; PPMS strengthens our ability to identify all of the work in our system programs.

PPMS Overview. The PPMS computer system uses the Hewlett-Packard 9830B with mass storage, line printer, plotter, and the CRT for data input. We provided identical hardware and software to the SPO program control office and to each of the major contractors. The PPMS software is driven to favor the man side of the man/machine interface. PPMS is an interactive system where the man makes all the decisions and the computer performs the calculations necessary to implement those decisions. The scope is strictly limited to the "front-end" activities from program planning through the SPD's procurement decisions; we strictly avoided attempting to use PPMS as a mechanism for tracking contractor progress since adequate mechanisms already exist in that area.

PPMS is designed to be extremely flexible, without any predefined hierarchy, so that by using plain English descriptive titles we would automatically construct a program breakdown structure. Consequently the PPMS is able to respond--no matter how the program manager structures his program--without imposing any constraints. Perhaps most importantly, the PPMS requirements were established by experienced program managers both in our SPO and in our contractor organizations. We began by asking ourselves "What are the basic questions that a program manager needs to ask and have answered before he can make an intelligent program decision?" The answers to those questions were ultimately formatted into the PPMS decision data matrix which forms the basis for the program data base used in the PPMS process.

The PPMS procedures and software provide these capabilities: segregates spacecraft programs; segregates program alternatives; segregates contractors; allows direct use of expenditure history in projecting funding profiles for similar hardware and services; includes all key information for decisions in unique decision packages; relates all decision packages to the actual program structure without constraining that structure; identifies decision constraints within programs and between programs; identifies, segregates, and computes funding for multiple program sources; enables systematic Government evaluation and modification of the contractor data base, based on experience with the contractor's past cost performance; enables convenient modifications to the program structure; permits exchange of data between programs with different data bases; enables rapid identification of tasks within the approved program, and enables prioritization of other tasks; provides special reports for various users which contain contractor information only, budget informtion only, and all decision information; relates decision packages directly to budget line items; provides a broad range of summation options to easily produce recurring reports while allowing random access summations for special cases; enables any data element to be used as a sorting parameter; enables routine mechanical conversion from one base year to the next; and strips sensitive Government data from the data base so it can be returned to the contractors for use in the next budget cycle.

All the capabilities I briefly outlined are grouped into major software modules; the process by which these software modules are employed is illustrated in Figure 2. The process begins with the contractor inputting data and using the summation capabilities to support his internal review; once complete, the data base is delivered, on the computer disc, to our program control office. We would print (and store for reference) a complete contractor report, and then run the freeze routine to protect the contractor data from inadvertent modification. We would then modify

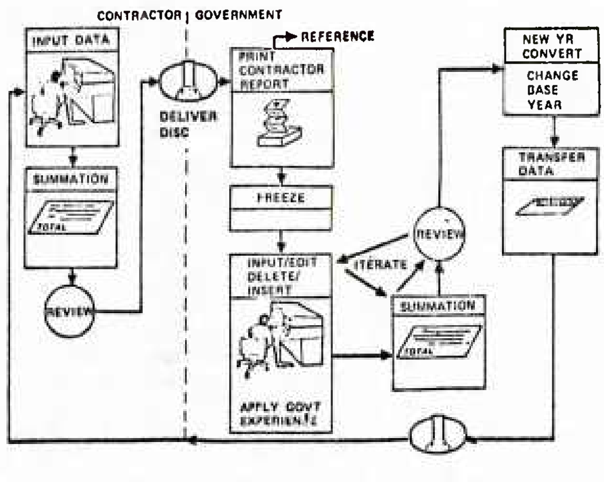

FIGURE 2. **PPMS COMPUTER SYSTEM OPS**

the data base as necessary, use the summation routines to prepare for the program manager's review, and iterate that process until he was satisfied. Once each year we would run the new year convert routine which would change the base year of the data and give us a new data base in the following fiscal year dollars. Each budget cycle we would run the transfer data routine which would would strip the sensitive Government data from the data base and rewrite the contractor information on a new disc which we would return to the contractor for use in the next budget cycle. This process minimizes the amount of unnecessary recurring effort and enables the contractor and the SPO to benefit from continuing learning over a number of budget cycles.

Now that I have outlined the PPMS capabilities and how the major elements are used together, I will give a few examples of how the basic capabilities are mechanized. I'll provide the greatest detail in describing the program structure as it's reflected in the PPMS data base. I'll also describe how inputs and modifications are made to that data base, and then briefly cover some of the output products. I will use diagrams which illustrate graphically how the system functions rather than attempt to use the computer printout products.

<u>Program Structure</u>. The structure of our satellite programs, as is reflected in the PPMS data base, is somewhat akin to the familiar work breakdown structure (WBS), although significantly expanded in scope and content. The basic building block is the program decision data matrix shown in Figure 3; this form provides the answers to the basic questions the program manager must ask before he can make an intelligent program decision. Having the right information in the data base is the key to the success of PPMS. The work sheets which were used by the contractor and SPO managers are exactly as shown on Figure 3. The computer printouts are also formatted as shown on Figure 3.

The program structure that is conceptually present in PPMS is illustrated graphically in Figure 4. It is like a WBS in that it has varying products; in the Program 555 example shown, the products shown along the "time now" line would be the Titan IIIC booster, Spacecraft 3, the spacecraft ground station operations, and the payload ground station operations. Of course, it takes many others to make up the complete program. PPMS has levels, just as does a WBS; at the system level you can see Spacecraft 3 and its long lead. At the subsystem level we have the navigation and the tactical communications payloads and their enhancements or modifications.

However, this program structure differs significantly from a WBS in several important ways. First, each of the items at the system and subsystem levels represents not a single piece of work but a grouping of information and costs into a single program manager decision package; this most nearly corresponds to the typical engineering change proposal (ECP).

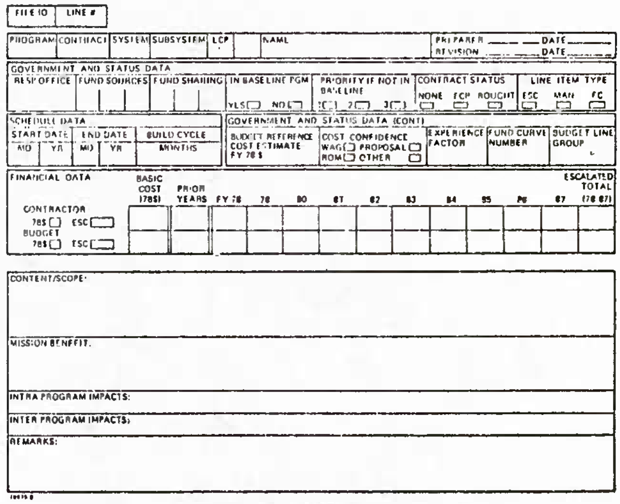

FIGURE 3. **PROGRAM DECISION DATA MATRIX**

Each of the items shown at the system and subsystem levels in Figure 4 represents the completed program decision data matrix (Figure 3). Similar decisions are grouped: for example, at the subsystem level we have the navigation payload for Spacecraft 3; there are also separate decisions for a new timing standard and a secure link for the navigation payload. Similar groupings exist for the spacecraft subsystems and for the tactical communications payload. Each of these decision items can be summed at higher levels: subsystems into systems; systems into contracts; and contracts into a total program. Only summations (not decision matrices) are used at the contract and program levels.

The most significant difference from a WBS is that the PPMS structure systematically recognizes the importance of time in assembling a complete program plan. That third dimension helps ensure that we are complete in our out-year requirements projections. This is clearly shown in Figure 4. When these particular data were developed in mid-1977, the "time now" line included the "contract" for the Titan IIIC, contract 0143 for Spacecraft 3, and contracts 0211 and 0212 for the spacecraft and payload ground station operations; these represent previously planned and budgeted activities were to be new FY 78 starts.

Spacecraft 4, projected for procurement about 18 months later, is shown under a dummy contract 0999 which provides a convenient collection level for cost data.

Note the similarities between Spacecraft 3 and 4: Spacecraft 4 contains all of the Spacecraft 3 decision matrices; and the basic spacecraft is still priced based on a repeat of Spacecraft 2. But note the differences: there are some additional decision matrices which represent new capabilities being added to the program effective with Spacecraft 4; a new SIOP communications payload

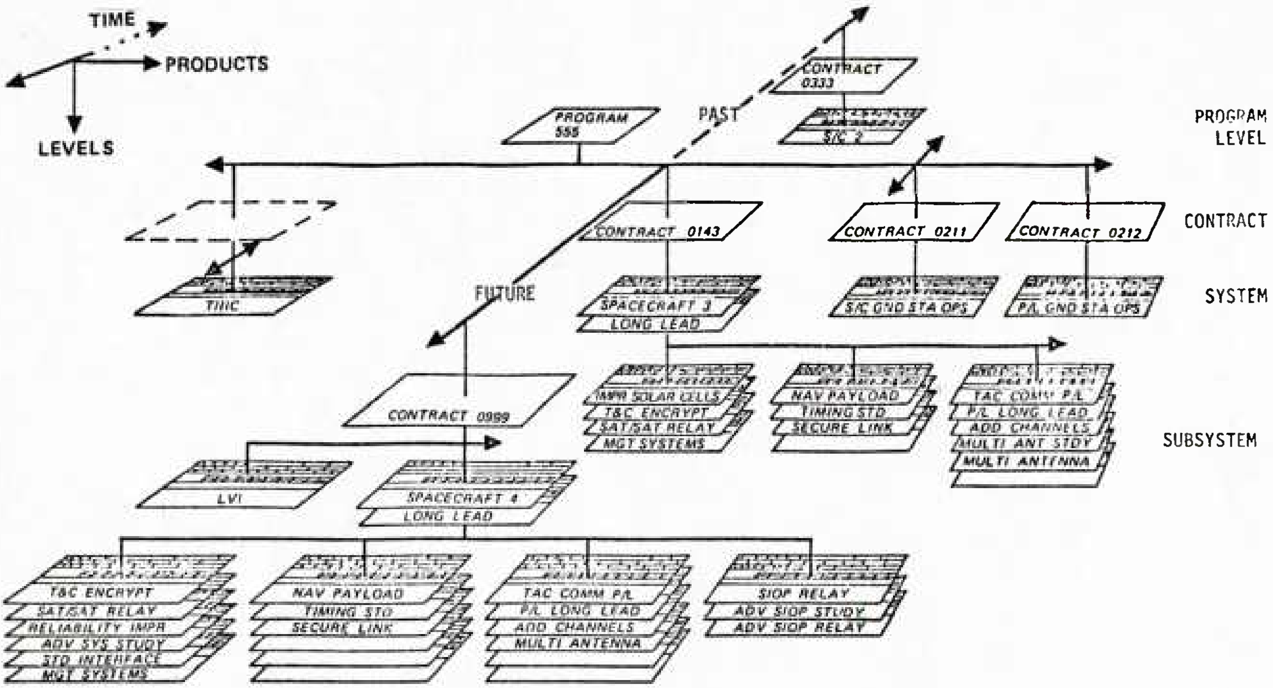

FIGURE 4. **SIMPLIFIED PPMS STRUCTURE**

DOD STANDARD SATELLITE PROGRAM (DOD SSP)

and additional spacecraft reliability upgrades are being considered. These similarities and differences are reflected throughout the PPMS structure; there is a program decision data matrix within every major area, such as the ground station and the launch vehicle--wherever one is required--which corresponds to the decision data matrix for each new spacecraft capability. This disciplined approach helps us get a complete picture of the cost of any new capability because we can identify all the work required to actually bring it on line and operational.

There are several things that I should point out briefly before continuing. In order to be complete in a program of this complexity it takes over three hundred individual decision matrices. The grouping shown in Figure 4 is a fallout of the plain English identifiers included in the decision data matrices; the computer automatically assembles the data in the appropriate way. The apparent contract structure shown here is not binding; for example, we show what appear to be associate contracts for spacecraft and payload ground station operations. This does not prejudge the program manager's final decision on the procurement of that capability; the option to procure by a prime/sub arrangement still exists. Further, all the levels (contract, system, etc.) in Figure 4 do not need to exist.

The program structure in Figure 4 may appear rather complex, but in fact it represents, in a rather general way, how all programs are really structured. It is not necessary to draw the picture each time in order to establish or understand the structure of the program. In fact we did not do it routinely; the structure is a natural fallout of PPMS.

<u>Data Base Input</u>. This is where the user begins. When we first implemented PPMS, we did this work ourselves. Once we had the PPMS operational, the contractors took over these early steps. I'll go step-by-step through building one decision matrix as it is done by the contractor.

Figure 5 breaks the decision data matrix down into sections, the first of which is shown in Figure 5a, "Identification Data." For example, 555B in the file ID block indicates uniquely the baseline alternative for Program 555. The line number is computer generated as each item is inserted and provides us a random access capability. The next line of data locates this decision data matrix in the PPMS structure (Figure 4). By inserting plain English titles in the decision matrix, we uniquely identify each program breakdown structure location. Of course we also track the source of information and the date it is prepared.

FILE ID	LINE #
555-B	320

PROGRAM	CONTRACT	SYSTEM	SUBSYSTEM	ECP	NAME	PREPARER	DATE
555	0143	S/C		0	SPACECRAFT 3	G3	03/05/77
						REVISION AV	DATE 03/10/77

FIGURE 5a. **DATA BASE INPUT**

IDENTIFICATION DATA

The "Schedule Data" section shown in Figure 5b includes the start and end dates, and for items in which we automatically compute funding distributions, a build cycle. The contractor determines the specific schedule milestones based on his assessment of what is required to meet the program objectives included in my planning direction to him.

SCHEDULE DATA				
START DATE		END DATE		BUILD CYCLE
MO	YR	MO	YR	MONTHS
10	77	03	80	30

FIGURE 5b. **DATA BASE INPUT**

SCHEDULE DATA

The "Financial Data" in Figure 5c is extremely straightforward; the contractor indicates whether or not he has escalated the data, and at what rate. There are several possible ways of inserting the data and instructing the computer how to do the mathematical manipulations; I'll discuss those a bit more in the next section.

FINANCIAL DATA	BASIC COST (78$)	PRIOR YEARS	FY 78	79	80	81	86	87	ESCALATED TOTAL (78-87)
CONTRACTOR 78$ ☐ ESC 7.8	78.2	0	39.7	31.6	8.3				79.6
BUDGET 78$ ☐ ESC ☐									

FIGURE 5c. **DATA BASE INPUT**

FINANCIAL DATA

The "Government and Status Data" section, shown in Figure 5d, includes several items of status entered by the contractor. Probably the most significant is to select the line item type; this determines the computation method. Selecting the escalation method indicates a constant cost activity which the computer will then inflate at the selected rate. The manual entry method permits the input of year-by-year data to fit any unpredictable circumstance. The fund curve method uses a historical profile, defined by the fund curve number, which will automatically compute the cost distribution based on the selected starting date.

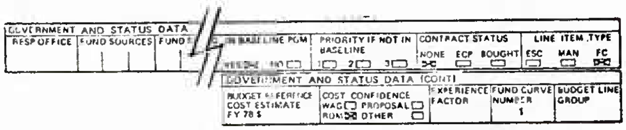

FIGURE 5d. **DATA BASE INPUT**

GOVERNMENT AND STATUS DATA

The "Narrative" section, shown in Figure 5e, provides a brief, but precise, description of what we are buying when we make this decision. It is, of course, written for a knowledgeable audience. Note the provisions for identifying both intra-program and inter-program impacts. Systematically thinking through these implications for every decision has proven extremely valuable in understanding the full implications of our program decisions.

CONTENT/SCOPE: SPACECRAFT 3 IS PRICED AS A REPEAT OF SPACECRAFT 2 EXCEPT THAT QUALIFICATION MOMENTUM WHEELS WILL BE REFURBISHED FOR S-3. COMMAND DECODER MODIFICATION COST INCLUDED IN T&C ENCRYPTION ECP. NAVIGATION AND TACTICAL COMMUNICATIONS PAYLOAD COSTS NOT INCLUDED.
MISSION BENEFIT: CONTINUED AVAILABILITY OF SPACECRAFT TO SUPPORT CRITICAL DOD MISSIONS.
INTRA-PROGRAM IMPACTS: ASSUMES APPROVAL OF T&C ENCRYPTION, IMPROVED SOLAR CELLS.
INTER-PROGRAM IMPACTS:
REMARKS: USAF/USA COST SHARING BASED ON JULY 1975 MEMO OF AGREEMENT OF HAVE USA FUND SPACECRAFT COST IMPACT OF INCORPORATING TACTICAL COMMUNICATIONS PAYLOAD. NOTE: THIS IS A FICTITIOUS EXAMPLE

FIGURE 5e. **DATA BASE INPUT**

NARRATIVE

This single decision data matrix describes the procurement of Spacecraft 3, along with its constraints and limitations. In a complex program like P555, over 300 individual decision data matrices are required for each of the three program alternatives. Of course, there is great similarity between decision matrices among the various program alternatives. Further, the second time through is considerably easier, and builds on the learning of the first cycle.

<u>Data Base Modification</u>. Once the contractor has finished providing the basic data required to assemble the program and estimate its cost, my program control office takes over and puts in the information that is unique to the SPO perspective.

Figure 6 illustrates how this particular decision data matrix is modified by my staff. In the "Government and Status Data" section in Figure 6a we would first identify the responsible office (in this case we use the initials of the responsible program manager). We also identify the funding sources and the percentage each would pay for this particular work.

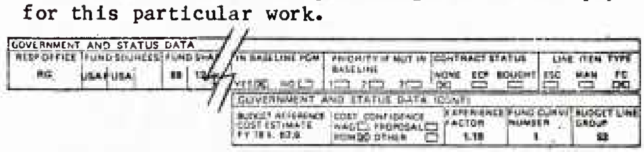

FIGURE 6a. **DATA BASE MODIFICATION**

GOVERNMENT AND STATUS DATA

We would also review, and probably modify, the contractor's priority designation. We use a very strict definition of priorities. An item in the Baseline program is something that we had previously included and which is required to meet our program direction. Items designated priority 1

are limited to those which are mandatory to meet our program direction, but have been previously omitted (these are rare). Priority 2 designates those items of value which would be considered for implementation in the program (such as optional capabilities). Priority 3 would be all others not seriously considered.

We might also choose to change the calculation method or to change the fund curve used for calculating spacecraft costs.

One of our most significant decisions is to select the multiplier to be entered in the "experience factor" block. In some cases, knowledge of the contractor and his performance on similar work make this a fairly straightforward process; that would allow us to focus on new development activity. We would carefully assess (with the program manager and his technical staff) the technical risk, the degree of the definition of the work, and the contractor's previous performance on work of this complexity; then our combined management judgment would be converted into a numerical estimate of the cost risk associated with the contractor's estimate. Finally, we would designate a budget line grouping so that we could do summations directly into the budget format using an automatic sorting routine.

We would then adjust the contractor "Financial Data," as shown in Figure 6b, to form a budget level projection which includes our risk assessments. Normally this would be done by the computer based on our assessment of risk, the schedule, the fund curve distribution of cost, and the inflation rate. In this particular example you see the spacecraft costs spread over three fiscal years. This is representative of the incremental funding authority which resides in this system program office.

FINANCIAL DATA	BASIC COST (78$)	PRIOR YEARS	FY 78	79	80	81	86	87	ESCALATED TOTAL (75-87)
CONTRACTOR 78$ ☐ ESC ☐									
BUDGET 78$ ☐ ESC 7.5	87.6	0	42.9	39.6	9.1				91.6

FIGURE 6b. **DATA BASE MODIFICATION**

FINANCIAL DATA

In addition to the items I've shown, we might modify any item of data in the decision data matrix. For example, if we were to change the spacecraft schedule, that would result in the fund curve computation giving us a different budget profile. We could insert or delete complete decision matrices; we could also add entire sections from other data bases when we have a portion of a program done by another contractor.

<u>PPMS Outputs</u>. The individual decision items which we have been discussing are useful for many purposes, but we also need a variety of data base outputs and summations in order to function effectively.

The first class of PPMS outputs includes outputs from the data base itself. For example, Figure 7 is the complete decision data matrix for Spacecraft 3. We could, of course, obtain a complete listing of the several hundred decision data matrices included in each program alternative. In addition to the Figure 7 format (which contains all the information we use for decision making in the program office) we could prepare selected specialized formats which suppress portions of the data. For example, a "contractor only" printout would suppress all budget related data, the government experience factor, the identification of the responsible managers, fund sources, and fund sharing, which are either unnecessary or undesirable for the contractor to know. A similar "budget" report, with different data suppressed, is also available. This combination of outputs enables us to communicate--from the same data base--with the contractor and with Air Force management, while still retaining within the SPO the information which is necessary to effectively manage the program.

We also provide a highly specialized directory of the individual decision data matrices. All the work in the program could be grouped by priority. This would enable the system program director to quickly review everything he has to do in order to meet his program commitments.

A number of specialized summations are available from PPMS. For example, we could sum selected subsystem level decision matrices into a subsystem cost. Of course, the capability exists to sum subsystems into systems; systems into contracts; and contracts into programs. Individual data matrices would be included or rejected based on priority. We could sum total costs and costs by each agency which funds part of the program. A special routine would sum items directly into budget line items.

We also have the capability to randomly select and sum individual decision matrices. This would be used to group the program options. I will illustrate how an option is formed. Consider an option for a secure communications link for the navigation payload beginning with Spacecraft 3 to restrict access to high fidelity navigation signals. We would assemble the option costs by selecting the secure link matrix from Spacecraft 3 and all subsequent spacecraft; a secure link upgrade to the spacecraft ground station and to the navigation payload ground station; the secure link operations from the spacecraft ground station and payload ground station operations contracts; R&D to develop a modification to the upper stage of the Titan IIIC booster in order to increase its throw weight capability to support the heavier spacecraft resulting from this payload modification; and the recurring booster modifications for the subsequent spacecraft. All of these activities, when summed together, would give us a total program cost of implementing the decision to add a secure link to the navigation payload. It is this systematic assessment of all the program impacts which is the most significant part of

FILE ID	LINE #
555 B	320

PROGRAM	CONTRACT	SYSTEM	SUBSYSTEM	ECP		NAME	PREPARER / DATE
555	0143	S/C		0		SPACECRAFT 3	PREPARER GH DATE 03/05/77 REVISION AV DATE 08/16/77

GOVERNMENT AND STATUS DATA

RESP OFFICE	FUND SOURCES			FUND SHARING			IN BASELINE PGM	PRIORITY IF NOT IN BASELINE	CONTRACT STATUS	LINE ITEM TYPE
RG	USAF	USA		88	12		YES [X] NO [ ]	1 [ ] 2 [ ] 3 [ ]	NONE [X] ECP [ ] BOUGHT [ ]	ESC [ ] MAN [ ] FC [X]

SCHEDULE DATA					GOVERNMENT AND STATUS DATA (CONT)				
START DATE		END DATE		BUILD CYCLE	BUDGET REFERENCE COST ESTIMATE FY 78 $	COST CONFIDENCE	EXPERIENCE FACTOR	FUND CURVE NUMBER	BUDGET LINE GROUP
MO	YR	MO	YR	MONTHS		WAG [ ] PROPOSAL [ ] ROM [X] OTHER [ ]			
10	77	03	80	30			1.18	1	53

FINANCIAL DATA

	BASIC COST (78$)	PRIOR YEARS	FY 78	79	80	81	82	83	84	85	86	87	ESCALATED TOTAL (78-87)
CONTRACTOR 78$ [ ] ESC [X]	78.2	0	39.7	31.5	8.3								79.5
BUDGET 78$ [ ] ESC [X]	87.6	0	42.6	39.8	8.1								91.5

CONTENT/SCOPE:

SPACECRAFT 3 IS PRICED AS A REPEAT OF SPACECRAFT 2 EXCEPT THAT QUALIFICATION MODEL MOMENTUM WHEELS WILL BE REFURBISHED FOR S-3. COMMAND DECODER MODIFICATION COSTS INCLUDED IN T&C ENCRYPTION ECP. NAVIGATION AND TACTICAL COMMUNICATIONS PAYLOAD COSTS NOT INCLUDED.

MISSION BENEFIT:

CONTINUED AVAILABILITY OF SPACECRAFT TO SUPPORT CRITICAL DOD MISSIONS.

INTRA PROGRAM IMPACTS:

ASSUMES APPROVAL OF T&C ENCRYPTION, IMPROVED SOLAR CELLS.

INTER PROGRAM IMPACTS:

REMARKS:

USAF/USA COST SHARING BASED ON JULY 1975 MEMO OF AGREEMENT OF HAVE USA FUND SPACECRAFT COST IMPACT OF INCORPORATING TACTICAL COMMUNICATIONS PAYLOAD.

NOTE: THIS IS A FICTITIOUS EXAMPLE

FIGURE 7. **DATA BASE OUTPUTS** "PRINT REPORT"

insuring that we project adequate budgets to meet our program commitments.

Summary. I have provided a brief overview of the PPMS capabilities and how they are used in managing a major space program. I must emphasize, however, that the focus is (and should remain) on PPMS supporting the SPO management process. Figure 1 is representative of that concept in that it shows the PPMS activities in the dashed blocks in their proper supporting role. It is absolutely essential that the program office understand its objectives and how to achieve them. There must also be considerable discipline within the organization because this planning task must go on even during times of great pressure to resolve immediate, and often serious, problems. Given that willingness and knowledge, PPMS (or its functional equivalent) can contribute significantly to establishing and maintaining a successful system program acquisition.

CONCLUSION

This description of PPMS and its use is, in reality, a description of how to establish a system program. To do so requires thinking on the broad est scale, well beyond the limitations established by current program direction, program funding, and current contract structures. Because of the breadth and depth of activity involved, this kind of thinking can be done only within the system program offices and not by the headquarters level staffs. However, thorough planning of this type should significantly improve headquarters level decision making on acquisition programs by providing a far more accurate representation of ultimate cost and capabilities.

I have had the good fortune to be associated with a number of major system acquisitions in disciplines varying from engineering to program control. Some of those programs have suffered from inadequate planning that underscoped the difficulty of the job and led to optimistic schedules and inadequate budgets. In each case, such problems resulted in significant perturbations to the program acquisition as major milestones had to be delayed, budgets had to be revised, and occasionally major reprogramming actions had to be taken. Each of these changes resulted in a reassessment of the program requirements and objectives and usually caused significant delays in achieving the improved military capability these programs were intended to provide.

I believe that a disciplined, systematic planning process--such as we employed in the Directorate of Advanced Technology--can significantly improve the quality of our program plans, schedules, budgets and, ultimately, our program execution.

Properly designed computer management aids, like PPMS, can strengthen that process. I hope that this paper will stimulate thinking about these important early steps in the program process. We have, over the years, learned how to manage our contracts once they have been awarded. I believe it is now time to focus on the planning process and strengthen it--through conferences such as the Defense Acquisition Research Symposium and through increased formal education activities in our Defense system management schools.

ASSISTANCE AND COOPERATIVE AGREEMENTS

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A PIPEDREAM GRANT THAT BECAME A PRODUCTIVE CONTRACT

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Washington, D.C. 20202

ABSTRACT

It is an unusual week that the media do not attack government spending abuses. A few of the reports result from spirited and muckraking journalism; nonetheless, the misuse of public funds is too prevalent.

But there are exceptions. One outstanding example is the national Reading is Fundamental (RIF) program. Fueled heavily with funds mostly from the new Education Department, RIF motivates children to read for fun and provides them with free books. RIF subcontractors, the reading catalysts for the operation, mushroom wherever the nation's communities determine there is a need - from the ghettoes of inner cities to the hollows of Appalachia.

RIF's humanitarian objectives have caught the eye and action of the Congress, the Executive Branch, the Federal government, corporations and non-profit organizations, state and local governments, and parents and community volunteer groups. In the parlance of Education Department officialdom, the multi-faceted RIF agreement is known as Procurement #300- 76 -0565 - the contract with a literate heart.

He ate and drank the precious Words -
His spirit grew robust -
He knew no more that he was poor,
Nor that his frame was Dust -

He danced along the dingy Days
And this Bequest of Wings
Was but a Book - What Liberty
A loosened spirit brings.

Emily Dickinson
Bequest of Wings

THE PROBLEM

A 1969 study conducted by the U.S. Office of Education identified 2.5 million students - nearly half the total enrollment of grades two, four and six in the then 9,200 school districts of the country - who were in need of special reading instruction to enable them to function at even minimum capacity.

In 1973, according to a report prepared by the Senate Committee on Labor and Public Welfare, an estimated 7 million elementary and secondary school children were in severe need of special reading assistance.

Reading deficiency today is generally regarded as the single most serious problem facing American education. In addition to the millions of school-age children who suffer serious reading defects, an estimated 3 million adult Americans are totally incapable of reading and writing. Another 20 million read so poorly they are classified as "functionally illiterate." These are Americans who cannot read bus schedules or street signs, fill out simple job application forms and whose primary use for newspapers is to swat flies or wrap fish.

In this country, beyond question, reading continues to be the totally critical skill for satisfactory functioning in society. The handicaps imposed on reading-deficient persons contribute substantially to national social and economic problems. These unfortunate men, women and children represent the fallacies of an education system that prides itself as being the best in the world and which spends more tax dollars on education than the rest of the world combined.

The Causes: The causes of illiteracy are muddled; the solutions are tangled. As H.L. Mencken put it: "For every deep and complex problem facing our society there is a simple answer - and it is wrong."

We do know that good teaching alone will not produce good readers; how often do we see a school's most creative teaching defeated by a simple refusal to read?

The costs of illiteracy are documented in the nation's welfare roles, the logs of prisons, court dockets, and the unemployment lists of our cities.

Our children need more than teacher-taught skills to read; they need desire and will and the cooperation of every school official and parent in America. When every citizen recognizes that "the literacy buck stops here" we will have an educated handle on the problem.

The Government Responds: The first nationally significant recognition of America's literacy crisis came in 1969, when U.S. Office of Education Commissioner James Allen publicly announced the complexities and extent of the problem. At that

time Allen set for the nation a target for the decade. "Education's race to the moon," he called it. The nation's educators had responded speedily to the Sputnik-created scientific and technological crises in the mid-1950's; it was time to play catch-up ball with literacy.

Allen called for 90 percent of all Americans over 15 years of age and 99 percent under 16 to read well enough to function as literate adults by 1980. The chief educator's lofty goal was perhaps earlier reflected upon by Lyndon B. Johnson - another respected friend of education - when Johnson issued this statement: "This country has the resources to do whatever it wants to do, if it has the guts to do it."

RIGHT TO READ PROGRAMS

Responsive to the nationally defined need, the Federal government in the early 1970's focused its attention on the illiteracy dilemma through the Right to Read Program administered by the U.S. Office of Education. Under Right to Read legislation, funds were provided to the Commissioner of Education for use at his discretion under the now-repealed Cooperative Reasearch Act. These monies augmented existing literacy efforts by providing:

- leadership training at State departments of education;
- school and community-based demonstration programs;
- projects in reading education for teachers and administrators;
- projects designed to have a national impact on reading activities and
- reading academies for persons not reached by schools.

The Congress later gave the reading programs greater stability and status by incorporating them into the National Reading Improvement Act under Title VII of the Education Amendments of 1974.

Despite limited appropriations for early Right to Read years, significant results were noted:

Minnesota: A February 1, 1974 news release, "Evaluation Shows Right to Read Effective Program for Pupils", revealed the following accomplishments:

Elementary pupils enrolled in schools with Minnesota Right to Read programs tend to achieve more reading objectives correctly than those pupils in non-Right to Read schools. Specifically, 3,000 students in grades 2,4 and 6 were evaluated on reading skills. Right to Read students outperformed their counterparts in non-Right to Read districts in 40 of 45 "significant" comparisons by a 2½ to 1 ratio.

Arizona: The original Right to Read Commission of Arizona recommended state legislation establishing reading proficiency standards for high school graduation. The State Board of Education established the following reading proficiency levels: At the end of the 12th grade a 9th grade reading proficiency was required; at the completion of the 8th grade a 6th grade level was established. At the onset of the Right to Read program in one pilot school only 16 percent of the students were reading at or above the 9th grade level; 38 percent were reading at the 3rd or 4th grade level. Two years later the pilot study group presented an entirely different picture: 60 percent were reading at or above the 9th grade level and only 2 percent reamined at the 3rd or 4th grade reading level.

Florida: Summaries of Florida's Right to Read effort indicate a noticeable imporvement in reading performance on vocabulary and comprehension in 1973-1974 as compared with earlier years. In every school and on every test more students scored above grade level than below.

New York: New York State indicated that reading was a top priority impacted upon by the Right to Read effort and other federally funded programs. Educators in the Empire state felt that the Right to Read "process" brought about significant change by reaching the people who were operating the school programs.

In New York declining reading achievements trends were reversed with highly significant diferences in the large cities where the reading emphasis was directed. New York City, for instance, reported an 8 percent improvement in third graders and an overall state-wide progress of 2 percent.

Oregon: Statewide assessment at the 4th grade level on a sampling basis of 8,000 students in Oregon indicated marked growth in reading. Right to Read school districts were getting highly positive results. Students averaged 2-3 months gain in reading achievement using the Stanford Achievement Test. In every case reading achievement was higher in Right to Read programs.

By June, 1975 the number of school districts participating in state Right to Read programs had increased to more than 3,400. In supporting Right to Read objectives, each program made a commitment to reading excellence; established a plan to attain that goal and initiated remedial activities to shore up exising reading deficiencies.

According to Edwin C. Cain, director of Federal-State programs for the Minnesota Department of Education, "no other program in the history of Congress and the Office of Education had positively affected so many teachers and students for such a small amount of money."

Few in the education community questioned the encouraging successes of early Right to Read programs. But Federal money for the reading programs was running short by the Fall of 1975. Without additional legislation funding would terminate in 31 states by February, 1976 and in the remaining states the following June.

CONGRESS ACTS

Under the leadership of Cong. Carl Perkins, Chairman for the Committee on Education and Labor, the 94th Congress entertained ~~two bills deemed~~ critical to the continuing Federal war on illiteracy:

. H.R.8304 amended the national reading improvement program by appropriating additional monies and providing more flexibility in the several types of reading projects eligible for aid.

. H.R. 9048 amended Title VII of the 1974 Education Amendments by adding the following new section:

"Inexpensive Book Distribution Program for Reading Motivation"

Section 724 (a) of the Inexpensive Book Distribution Program (IBDP) authorized the Commissioner of Education to contract with non-profit groups or public organizations whose primary purpose "is to motivate children to read".

Passage of the IBDP legislation authorized an appropriation of $8 million for the first year of the program and $9 million for each of the two subsequent years.

Testifying at the IBDP Oversight Hearings was Mrs. Robert McNamara, chairperson of an organization called Reading is Fundamental (RIF), whose primary purpose was to motivate children to read.

Mrs. McNamara, wife of the World Bank President, presented her convictions that RIF - a non-profit organization which had been providing free books to kids since 1966 - should have Federal support.

And she made believers out of the Congress, too.

Said Sen. Walter Mondale: "...this legislation also authorizes long overdue Federal support for Reading is Fundamental. This successful program, known as RIF, has had an unparalleled record of accomplishment."

Cong. Perkins strongly supported the RIF concept: "The Committee has been very impressed by Reading is Fundamental's success and we believe that this small amount of Federal funds will be spent in continuing RIF's program or in funding a similar program."

EARLY RIF

The initial concept for RIF dates back to 1966 when Mrs. McNamara was a reading teacher aide in the Urban Service Corps in Washington, D.C. She observed that many of her pupils - most of whom were from economically disadvantaged environments - were not interested in school-provided textbooks. They did, however, display enthusiasm for the books which Mrs. McNamara often brought from home.

Mrs. McNamara's observation detonated the concept for RIF which had its genesis as a pilot project in the nation's capital.

Under Mrs. McNamara's perservering guidance early RIF funding came from such sources as the Meyer and Cafritz foundations. The program met with rapid and striking success, enough so that subsequent grants from the Ford Foundation facilitated program expansion to a national level. Even the U.S. Office of Education kicked in $80,000 in grant money to the RIF kitty - not a large amount of money from a Federal source - but enough to make reading more than a pipedream fantasy for many thousands of youngsters.

In its first 10 years of operation, RIF distributed 5½ million books to more than 3 million children, and had grown from one test project in the District of Columbia to nearly 400 programs nationwide.

Despite limited funding early RIF had accomplished subtle miracles; furthermore it had filled an overlooked gap in the nation's reading programs - that of making reading FUNdamental. RIF's idealistic purpose was summed up by one inner-city ghetto youngster who was asked why he was reading a particular book. Back shot the no-frills answer: "Because I like it."

Getting children to like to read remains RIF's purpose today.

In 1976, as a fully justified noncompetitive procurement, RIF was awarded Contract #300-76-0565 by the U.S. Office of Education Right to Read Program. To the Grants and Procurement Management Division contract specialists who handle the day to day business of the award, RIF became known as the contract with the literate heart.

RIF TODAY

When the Office of Education escalated the funding of RIF in 1976, it had nearly 400 programs operating in 47 states at 1,332 sites, and engaging the time and commitment of more than 8,000 volunteers. Today its projects involve more than 3 million children at 13,000 sites in 11,000 schools and all 50 states.

As the New York Times recently put it, "RIF seems to be one of those rare examples of how the Government has joined with the 'grass roots' community and virtually everyone has wound up applauding..."

How It Works: Any of the nation's 16,000 plus school districts, state education departments or other private or public agencies can apply to start a RIF program and subsequently qualify for Federal funds with which to purchase books. In procurement jargon RIF is the prime contractor and the various districts, departments and other groups okayed by RIF become the subcontractors.

The potential subcontractor writes to RIF's National Headquarters in Washington, D.C., requesting a proposal form and instructions. The proposal is simple and requires minimal paper

work on behalf of the sub. In the proposal the subcontractor - more often than not a community group - describes its plan including the number of youngsters served by the project, the amount of local funds it expects to raise, and the amount of Federal matching funds required. For every dollar raised by the local project, the Education Department adds another three dollars.

If RIF approves the proposal, the group signs a subcontract with RIF to operate a 12-month project. The group also agrees to sponsor book distribution days with reading-related activities designed to motivate the youngsters to read.

RIF negotiates agreements with book publishers and distributors that promise good discounts and services for local projects. As new companies sign agreements, RIF prepares a brief profile of their services. The profiles are periodically updated as services change and new companies join the program.

The purchasing groups may order books only from RIF-approved profiles. The limit for paperbacks or hardcovers is $3 . Paperbacks get more than 90 percent of the action.

Purchasers who cater to handicapped youngsters may order literary audio-tapes, records and "talking books", as well as books in Braille. The price limit after discount is $7.95 for audio materials and $50 for Braille books.

Book discounts range from 10 percent to 60 percent from the 260 publishers and distributors who have qualified as RIF suppliers. The list spans Aardvark Media, Inc. to the Zuni Language Development Program.

How Matching Funds Work: Federal funds are allocated for the express purpose of purchasing inexpensive books for a given project. Requests for funds must be greater than $100 but not to exceed $150,000 during the course of the subcontract. Local fund-raising sources can include individuals, foundations, businesses, and states or local governments. In exceptional cases, funds from other Federal programs can be matched if the Federal agency which provides those funds approves their use specifically for RIF programs.

Federal matching funds and the local monies comingled with them may be used only for book purchase. They cannot pay staff salaries or other operating expenses.

The subcontractors forward invoices for the books they have purchased along with their checks for one quarter the amount due the supplier or distributor. RIF then pays the suppliers the remainin three quarters due from its federally fueled bank account and also includes with its payment the subcontractor check for the balance.

All invoice work is handled at RIF headquarters where a staff of 50 shuffles the paper work and plans for the future.

Interestingly enough RIF's key positions are filled by women. RIF President Ruth Graves, as charming as she is professional, brings to the organization a depth of experience that spans both the public and private sectors. She has been a teacher of adult dropouts, pre-school children and exceptional children.

Barbara Atkinson is director for policy review where she plans, develops and implements model RIF programs.

Rounding out the top RIF positions are Carolyn Gunn, director of field services; Tina Mead, director of administrative services, and Kristine Wilcox who heads up the division of publications.

Not to be outdone, the Education Department has cast top female talent to administer the RIF program. Helen O'Leary is the RIF project officer under the Right to Read program while Queenola Tyler competently oversees RIF contract matters for the Department's Grants and Procurement Management Division.

The RIF program is well respected throughout the fledgling Department. Secretary Shirley Hufstedler proudly displays a RIF poster on her office wall.

Spreading The Word: Although the percentage of school-sponsored RIF projects is increasing, a growing number of civic groups, church organizations and special interest groups are initiating RIF projects. To assist them, RIF program specialists hold workshops, speak at conferences, mail information and spend countless hours dispensing information on the telephones.

RIF also informs the public about its activities through contact with national associations, conventions and articles in their house publications. In 1979 RIF exhibited at about 15 major conventions of professional and civic organizations. Book suppliers and distributors often voluntarily provide their communities with information on RIF programs at the local level.

RIF and the Smithsonian: RIF is associated with the Smithsonian Institution in Washington, D.C. The Smithsonian, in exchange for a fee, serves as RIF's Fiscal agent.

The administrative arrangements between RIF and the Smithsonian state that the fee paid by RIF to the Smithsonian will cover such items as office space, telephone service, and normal accounting services including the maintenance of account books, receiving and disbursing cash, processing payrolls, preparing monthly and annual financial statements, and the filing of special reports.

Public Service: Since 1971 RIF has been approved by the Advertising Council. The Al Paul Lefton Company serves as the volunteer agency and produces television, radio and print ads. Since 1971 RIF has received more than $9 million in free radio, television and print space donated in the public service. Tennis great Arthur Ashe and television comedienne Carol Burnett have

provided their time, talent and energy to recent public service efforts of RIF. Ashe promoted the program through radio and Burnett through television.

Ed Asner, who plays the feisty city editor of the Emmy award-winning television series, "Lou Grant", is the spokesman for RIF on radio and television for 1980.

Asner's message is clear, simple and strong: "Get involved with RIF", he tells the public. "When you give a kid a book, you get him to open his mind. And his future. You give him a chance to get somewhere in this world. Give a kid a book and you'll give a kid a break...join the RIF program in your community."

RIF SUCCESSES

In 1980, the year earmarked by Office of Education Commissioner James Allen for his literacy goal, RIF projects in 50 states will send more than 11 million paperback books to such remote places as the bottom of the Grand Canyon, where books will be carried by mule to a tribe of Havasupi Indians.

"I have never received the satisfaction from any program that I've been associated with as from your program," says Robert O. Samsel, Federal Programs Coordinator for the Berwick, Pa. school district.

"The cooperation of the school administrators, teachers, parents and students has been fantastic," according to Samsel. "Several parents related little incidents about how their child would read to them, or spend more time with books, which they credit to Reading is Fundamental."

"As a result of this program some parents have become more aware of the need for setting an example for the child in the home." He added, "The program has brought about amazing results and I am certainly very happy to have been a part of it."

Samsel commented that response from local businessmen, press and parent groups in helping to raise funds for the programs was excellent.

Pamela Sacks, part owner of "The Cheshire Cat," the only children's bookstore in Washington, D.C. had this to say about RIF: "...RIF is the embodiment of an idea that I experienced first-hand when I was a librarian at a private school here. There was one little boy, a scholarship student at the school, who had taken three books out of the library. But he refused to bring them back. Each time I asked him where they were, he made an excuse. Finally I realized that he wouldn't bring them back because he loved them too much. So I told him that if he would bring them back I would give him three paperback copies that he could keep for himself."

"The very next day, the three library books were returned. But before he would hand them over, he took my three paperback duplicates and lined them up against the originals and compared them - first picture for picture, and then line for line, to make sure that the ones I had given him were absolutely the same. Only then would he hand over the library copies. It was the most touching thing I have ever seen. Those three paperbacks were the beginning of his own library." (reported in the <u>New York Times Book Review</u>, Spring 1980.)

<u>Have The Federal Dollars Helped?</u>: The Federal dollars matched with RIF-raised project funds have increased dramatically the number of communities that can bring RIF to their young people. In the first two years of federal funding, the number of RIF projects jumped nearly 600 percent and continues to increase according to monies available.

Federal dollars have also made it possible for RIF to serve many more of the nation's hard-to-reach youngsters who often need books the most - the children of migrant and seasonal farm workers, for instance, and handicapped children and those in correctional institutions.

Joan Mondale, wife of the vice president, who served on the RIF Board of Directors and is now a member of its Advisory Council, characterizes RIF as "one of those examples of the best of cooperative efforts between private citizens and the Federal government."

In carrying out its basic charter, RIF has accomplished more than getting children into books. It has grown into a highly effective catalyst in individual communities throughout the country involving thousands upon thousands of the parents of the children served. The parents are not only helping to operate individual projects but also have themselves begun to read. RIF has involved thousands more - educators, librarians, business and civic leaders, and members of national organizations - all of them working together in communities to support RIF's motto: "If America is to grow up thinking, Reading is FUNdamental."

The RIF success story clearly demonstrates that one sure-fire means of turning America into a nation of readers is to enlist the spontaneous cooperation of private citizens and government at all levels.

RIF further substantiates that well planned and carefully spent taxpayer dollars can contribute to the solution of national socio-economic problems.

Originally nourished by mostly private sector grants the RIF program subsequently and cautiously mushroomed into a competently managed, multi-million dollar Federal contract administered by prudent professional contract managers in the private sector and government.

Their combined efficiency is poignantly echoed by the little ghetto child who remarked that he now reads because "I like it."

* * *

THE IMPACT OF P.L. 93-352 ON BIOMEDICAL RESEARCH CONTRACTS

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ABSTRACT

Biomedical Research Contracts were made subject to statutory requirements for scientific peer review with the enactment of P.L. 93-352, the 1974 amendment to the National Cancer Act. This has necessitated changes in the method of project selection and review on biomedical research contracts of NIH. As respects grants, the method of review was not altered appreciably pursuant to the statute, as NIH had already had a system of scientific peer review, conforming to the statutory standards. Another statute, the Federal Advisory Committee Act, has also caused revisions in review procedures.

STATUTES AND REGULATIONS INVOLVED

1. Amendments to the National Cancer Act of 1974
P.L. 93-352, approved July 23, 1974, the Amendments to the National Cancer Act of 1974, provides, in part, as follows:

   "... not more than one-fourth of the members of any peer review group established under such regulations shall be officers or employees of the United States." (Sec. 472 (c))

   This is the basis for the requirement that at least 75% of peer committee members be non-Federal Government employees. This statute is also the basis for the requirement that the Secretary, HEW, by regulation, provide for scientific peer review of R&D contract projects.

2. The Federal Advisory Committee Act
On October 6, 1972, there was approved the "Federal Advisory Committee Act," P.L. 92-463. It established certain requirements of openness and accessibility by the public to proceedings of Public Advisory Committees. These requirements include the advanced publication of the dates and place of such meetings and the chartering of such committees with the Office of Management and Budget. Excluded from the definition of Public Advisory Committees is any committee composed wholly of officers and employees of the Federal Government.

   The type of committee herein described as a "Peer Committee" is subject to the Federal Advisory Committee Act. It has as its function the review of R&D proposals for technical merit and is subject to the Federal Advisory Committee Act's requirements for chartering with the Office of Management and Budget, as well as the publishing of an advance public notice of meetings. By contrast, source evaluation groups are not subject to the Federal Advisory Committee Act because such groups are composed wholly of Government employees.

3. Rule-making on Scientific Peer Review of Grant Applications And Contract Proposals (DHEW)
This was printed, by DHEW, in the Federal Register, February 4, 1978. It contains an implementation of P.L. 93-352, mentioned above. It also covers conflict of interest matters respecting peer committee members. It defines R&D for purposes of the Statute. (Rule is entitled: "Scientific Peer Review of Research and Development Contract Projects").

PROBLEMS FOR DISCUSSION

1. The Administrative Complexity Resulting from the Transfer of Program Decision-making from in-house Committees to Committees Composed of Part Time Outside Advisors
Is this administrative burden excessive, and does peer review threaten to compromise administrative flexibility, and proper ascertainment of funding priorities?

2. The Conflict of Interest Problems Involved in Having University Faculty Members Serve on Committees Which are Charged with Review of Contract (or Grant) Proposals from their own Institutions
There would be discussion of the methods of resolving these conflict problems, including the rules which have been developed on this for both grants and contracts on potential conflicts of interest by committee members.

3. Lead-time Requirements for Review Committee Meetings in Order to Meet the Federal Advisory Committee Act's 30-day Advance Notification Requirement in the Federal Register
This is a burdensome requirement, at least at the outset, in the period of familiarization with these requirements.

4. Definition of R&D Project, as Distinguished from Resource (Support) Project
The matter of reaching a definition of R&D affects the jurisdiction of the chartered peer committees. The problem is that the definitions used heretofore by NCI and that contained in the DHEW proposed rule are divergent, especially as regards Resource (Support) Projects.

5. Pressure from OMB to Reduce the Number of Committees
Does this affect the degree of specialization of the committees, and impede the adequate scheduling of projects for review? Administrative solutions to this: Establishment of omnibus committees to replace numerous highly specialized committees. Is this merely a palliative, contributing to poorer science reviews?

6. Responses to Past Criticisms from Science Magazine and Academic Community
Does the statutory solution really solve the problem? The problem of possibly inadequate review of research contracts was posed earlier in an article in Science Magazine. This article was concerned, in part, with the possible "buddy system" in the then existing NCI procedures for contract review. There was also the "authorship" problem, involving NIH personnel as claimed originators of an idea or an article. Have these conditions been resolved by the statute or otherwise?

7. Is There a Power Struggle Among Governmental Science Administrators?
If so, how is this reflected in decisions affecting grants versus contracts policy at NCI? There is also the position of the National Cancer Advisory Board to be considered.

8. Was the Old System of Peer Review in Fact Superior to the Statutory System?
Did it accomplish the same purpose of "peer involvement," while permitting better control by "program" administrators of NCI programs they administer?

9. Are Budgetary Priority and Allocation Considerations Transgressed By Peer Committee Decision-making?
Do the peer committees address priorities in a piecemeal fashion, rather than in regard to overall budgetary priorities? Are in-house staff reviews still effective, given the new peer structure?

10. The Problem of Conflicts Between FPR Requirement for Oral and Written Discussions and Review of Revised Proposals by Peer Committees
Are meaningful discussions as envisaged by GAO under P.L. 87-653, and the FPR really possible under peer review? Is peer committee review too unwieldly for such proposal-revision purposes? Does this limit the flexibility of the contracting officers in deciding upon awardee, or does it in fact expand his role at expense of the "program" and "peer" committees? Is "best and final" offer concept incorrectly applied to R&D?

11. Other Agency Practices
Comparison with in-house non-peer reviews by other agencies, such as ERDA, NASA. These agencies are not subject to the statutory peer review requirement. Will Congress move to require peer review in their decisions on research contracts? If so, how much damage would be thereby done to their programs, if any?

12. Possible Recommendations for Statutory and Regulation Changes
Examples follow:
   (a) Should the statute P.L. 93-352, be made applicable only to research, not to development?
   (b) Should the statute confine peer review of broad programs rather than proposals?
   (c) Should it give larger role to Government scientific administrators?
   (d) Should the FPR be revised to exclude biomedical R&D contracts from oral or written discussions requirement?

Innovative Competitive Solicitations for Contracts and Cooperative Agreements

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ABSTRACT

DOE has developed innovative procedures to solicit proposals for research and development activities leading to the award of contracts, cooperative agreements or grants. One of these mechanisms called Program Research and Development Announcements (PRDAs) has proven to be an extremely valuable tool in soliciting proposals from individuals, private entities, and public entities (excluding Federal Agencies).

Pursuant to Section 107(a) of the Energy Reorganization Act of 1974 (P.L. 93-438) the Energy Research and Development Administration (ERDA), and now Department of Energy (DOE) was authorized to make arrangements (including grants and cooperative agreements as well as acquisition contracts) for the conduct of research and development activities. In implementing the broad authorization of the Act, ERDA developed procedures independent from the procedures traditionally used when the Government is able to predetermine specific requirements. One such procedure developed and promulgated first by ERDA-PR Temporary Regulation No. 16 on March 16, 1976, and subsequently incorporated into the DOE Procurement Regulations is the Program Research and Development Announcement (PRDA).

PRDA's are a mechanism to provide potential proposers with information concerning the DOE's interest in entering into arrangements for research, development, and related projects in specified areas of interest. PRDAs are used to inform individuals, private entities, or public organizations (including State and local governments, but not Federal agencies) of DOE's program goals and to solicit solutions in the proposer's own technical and business terms. Some projects so suggested may be assistance oriented involving proposer's projects needing only DOE financial assistance. Other proposals may contemplate the sale of Research and Development services to DOE. Accordingly, multiple grants, cooperative agreements, or acquisition contracts may result from a given PRDA.

If the intended relationship is expected to be a financial assistance instrument such as a grant or cooperative agreement, the DOE Assistance Regulations in 10 CFR 600 are followed. If the intended relationship is expected to be an acquisition contract, the DOE Procurement Regulations in 41 CFR Chapter 9 are followed. The DOE requires that PRDAs indicate whether the intended relationship is expected to be of procurement or assistance and state which of the regulations will govern the resulting award.

The PRDA is somewhat different from the conventional Request for Proposals (RFP) in that the specific need or solution is not sufficiently defined or known to permit traditionally focused competition. Selection is based upon the optimum (or best) mix of R&D projects to be funded with the limited resources of the program.

Selection of proposals, by necessity, involves broad discretion and judgement since the choices may have to be made among dissimilar concepts, ideas, or approaches. Furthermore, it is DOE's desire to encourage the involvement of small business concerns and small business concerns owned and controlled by socially and economically disadvantaged individuals in research and development undertaken pursuant to PRDAs. DOE expects that proposals in response to a PRDA may be totally dissimilar in concept and approach. While comparable aspects of proposals are ranked and scored in accordance with the evaluation criteria contained in the PRDA, selection is ultimately based upon program policy factors specified in the PRDA.

DOE-PR 9-4.5802-1(c) sets forth the conditions for use of a PRDA. They are:

(1) Research and development is required within broadly defined areas of interest to support program goals but it is difficult, if not impossible, to describe in any reasonable degree of detail the nature of the work contemplated because of:

(i) The multiplicity of possible approaches, within the current state of the art, available for solving the problems;

(ii) the desirability of involving a broad spectrum of organizations in seeking out solutions to the problems posed;

(iii) the expectation that many individual proposers will have unique qualifications or specialized capabilities which will enable them to perform portions of the research or development program (without necessarily possessing the qualifications to perform the entire program) so that the overall support may be broken into segments which cannot be ascertained in advance; and

(iv) the desirability of fostering new and creative solutions;

(2) Consistent with (1) above, it is anticipated that choices will have to be made among dissimilar concepts, ideas, or approaches; and

(3) it is determined that a broad range of organizations exist that would be capable of contributing towards the overall research and development goals identified in (1) above.

Each PRDA includes the following information in the solicitation:

(1) A unique number for identification purposes;

(2) place for and manner of proposal submission;

(3) a statement notifying potential proposers that an announcement does not commit DOE to pay any proposal preparation costs and that DOE reserves that right to select for award or support any, all, or none of the proposals received in response to an announcement;

(4) a time schedule for submission of, and action on, proposals;

(5) A summary of the area(s) of program interest, expanded as appropriate, to include problems and objectives;

(6) other information, terms and conditions which apply to the particular PRDA;

(7) information to be provided in the proposals;

(8) a late proposal provision;

(9) evaluation criteria; and

(10) program policy factors.

Program policy factors (DOE-PR 9-4.5804(d)), are those factors which, while not appropriate indicators of a proposal's individual merit (e.g., technical excellence, proposer's ability, and cost), are relevant and essential to the process of choosing which of the proposals received will, taken together, best achieve the program objectives. All such factors are predetermined and are specified in the notice so that proposers will be aware of factors essentially beyond their control which will affect the selection process. The following are examples of typical program policy factors:

(1) It is desirable, because of the nature of the energy source, the type of projects envisioned, or limitations of past efforts, tc select for award or support a group of projects with a broad or specific geographic distribution;

(2) it is desirable to select for award or support (for reasons which must be stated) projects from diverse types and sizes of proposing organizations;

(3) it is desirable to select for award or support a group or projects which represent a diversity of methods, approaches, applications, or kinds of work; and

(4) it is desirable, due to the nature of certain projects of proposing organizations, to select for award or support duplicative or complementary efforts or projects.

While the DOE and its predecessor ERDA have made successful use of the PRDA method of soliciting proposals, it should be noted that many "unknown unknowns" still exist regarding the PRDA process. A potentially troublesome issue is whether or not the GAO bid protest procedures, 4 C.F.R. Part 20, apply to protests in connection with PRDA's, when the arrangement is expected to be a cooperative agreement.

This issue was not resolved by GAO Protest B-193500 as that protest did not result in a published GAO decision. The purpose of the PRDA in this instance was to obtain proposals on which cooperative agreements could be negotiated. DOE intended to fund assessments of existing dam sites where the proposer was in a position to develop hydroelectric power facilities should the assessment indicate low head hydroelectric generation would be feasible. DOE sent out approximately 2000 copies of the PRDA and 203 timely proposals were received. Of the 203 proposals, 189 met the qualification criteria of the PRDA and 56 proposals were selected for negotiation of cooperative agreements. A total of 54 cooperative agreements

were awarded with one proposal being withdrawn and the other proposal being the subject of the protest.

Ultimately, DOE determined for programmatic reasons that no award would be made in that instance. Accordingly, the GAO took no further action on this matter. The protest, however, did bring into focus the issue of first impression involving GAO jurisdiction over the award of a cooperative agreement under a PRDA.

In this regard, the Controller General of the United States has consistently held that it will not inquire into the propriety of a particular grant award notwithstanding its exercise of jurisdiction over contracts issued by the Federal Grantee. Under GAO Protest B-193500, the DOE contended that cooperative agreements, as described within the Federal Grant and Cooperative Agreement Act of 1977, Public Law 95-224, February 3, 1978, 41 U.S.C. 501 are like grants in that both are legal instruments in which the principle purpose is the "transfer of money, property, services or anything of value to the State or local government or other recipient in orer to accomplish a public purpose of support or stimulation authorized by Federal statutes rather than by a acquisition, by purchase, lease, or barter, of property or services for the direct benefit or use of the Federal Government...". The DOE suggested that the Comptroller General determine not to take jurisdiction over award of cooperative agreements as DOE can then independently consider comments and complaints regarding its cooperative agreements as with grant awards.

Another issue in connection with PRDAs which has not been tested before the GAO is the matter of program policy factors. These "super-criteria", (not indicators of a proposal's individual merit) are essential to the PRDA process. To the extent that program policy factors pass the test of time, such "super-criteria" may prove useful in competing alternative system design concepts, pursuant to OMB Circular A-109, using the traditional RFP approach.

In conclusion, ERDA and DOE have considerable experience with PRDAs. These innovative solicitations have assisted DOE to achieve its programmatic objectives. PRDAs permit the competitive solicitation of broad ranging proposals from individuals, private entities, and public organizations such as State and local Governments. It is the author's opinion that PRDAs are a valuable tool to DOE which warrant additional research regarding the benefits of broader use of PRDAs by civilian and defense agencies. It would appear that PRDAs may have particular application to major system acquisition where early competition of alternative system design concepts to satisfy mission needs is required.

A NAVY MODEL FOR DECISION-MAKING IN ACQUIRING MAJOR SYSTEMS

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ABSTRACT

The essence of achieving affordable Navy systems is to:

- Verify the mission deficiency to be met
- Exercise choice among competing conceptual or design alternatives for meeting the deficiency
- Utilize cost as a design goal and as a basis for evaluating alternatives
- Identify precisely the life-cycle cost implications of early design decisions.

The requirements to assess affordable systems are implicit in the policy objectives of OMB Circular A-109.

To date, the Navy has not responded with an integrated management model for achieving the objectives of A-109 and, therefore, managing the characteristic of affordability in major systems acquisitions.

Research suggests the absence of useful coverage, both organizationally and "culturally", in the Navy to meet the decision-making implications of OMB Circular A-109.

What is proposed is a model of both separate and shared responsibilities for "user" and "producer" functions in the Navy to meet Navy mission responsibilities while at the same time meeting the OMB policy standards for major systems acquisitions. This can be achieved only by special statesmen-like groups representing multiple CNO and CNM responsibilities who are appointed by and report to the CNO.

The Decision Maker. There are radical changes for both Navy and private sector management concepts brought about by the decision-making logic proposed in OMB Circular A-109. The basic change is to place the project management concepts on a "pro-active" basis rather than a "reactive" basis. The practical implication of this change is to take the project management concept away from all-consuming involvement in problem coping and introduce it early enough in the decision-making process to achieve problem avoidance as well as problem solving. This is a landmark change in management orientation and contains the best hope for reform in the adverse characteristics that have plagued major systems acquisitions for the past twenty years.

The net of surveys and studies in the area of project management suggest that the use of the term "Navy project manager", in the past, is really a misnomer. Based on the timing of introduction of the project manager into the decision-making process and the latitude for decisions left to the project manager, it would have been more accurate to designate the function as "Navy marketing manager" for a system that was pre-determined.

The theoretical benefits associated with project management, such as control of the interrelationships and interdependencies of competing aspects of cost, schedule and performance goals, were denied to the project management concept.

Little if any latitude of judgment is actually open to a project manager who is dealing with a locked-in, pre-determined systems solution to a "given need".

The so-called "private sector supplier" counterpart to the Government in-house project manager, is a "clone" of the government project manager. Over the years, the defense/aerospace industry has become an extension of the Government bureaucracy and the so-called private sector project manager in this context exhibits the same constraints on judgment in pursuing a prescribed system solution to an assumed Government problem as a Navy counterpart.

Most private sector management complaints that have occurred over the years have to do with the proliferation of controls designed to achieve this "cloned response" from the private sector. Many commentators have assessed this relationship; the most telling being Bruce Smith, in his work The Dilemma of Public Accountability in the Modern Contract State, in which he assesses the latitude of judgment of managers in the defense-aerospace industry as less than that of their counterparts in socialized industries in Great Britain.

Indicated Changes. The accumulation of "lessons learned," and especially the insights represented by the Commission on Government Procurement treatment of major systems, directly lead to the issuance of OMB Circular A-109 and resulting 1980 DOD revisions to the 5000 series directives on major systems acquisition policy.

Inherent in these changes is a change in span of management to include the "entire acquisition process" and involve the project manager, for the

first time, in the requirements determination process.

An analysis of changes under A-109 suggests two phases in the acquisition process involving two distinct but over-lapping aspects of project management. The two aspects are "mission management" and "product management".

Mission Management. Mission management deals with front-end decision making including those decisions that precede the formal designation and chartering of a "project manager". Even under these revised concepts, a designated "project manager" follows formal confirmation of a mission need by OSD. Assignment of a project manager after such formal confirmation is for the purpose of devising an acquisition strategy in pursuing conceptual or design alternatives leading to a cycle of milestone reviews and validation by OSD in determining a final system choice.

The concept of "mission management" contains the essence of substantive change in Navy major systems acquisitions. Traditionally "needs" have had their earliest expression as specific product answers to perceived mission deficiencies. There is no strong Navy heritage for establishing alternative, competitive approaches to meeting mission needs. There is little tradition for placing total design responsibility with private sector suppliers. In the past, a typical Navy systems design requirement was derived from multiple government and non-government sources which resulted in an inability to establish design responsibility or subsequent contractual integrity.

Past procedures usually focused the Navy on a single answer to an assumed need rather than on a search for the best answer to a confirmed need. Typically, the single-answer, assumed need dilemma was inherited by the assigned project manager who, therefore, had little chance to control resulting characteristics of schedule slippage, performance shortfall and cost growth that so often have plagued Navy programs. These adverse characteristics were built into the decision-making process which took place before the project manager was ever brought aboard.

Revised OMB and OSD procedures are aimed at protecting the project manager from "locked-in problems" by affording the opportunity to protect programs from fragmented and premature decision-making.

Milestone "0" approval, the formal OSD acceptance of a Navy need, results in a grant of authority to a project manager to explore alternative system conceptual or design approaches. Program objectives in terms of capability, schedule and cost goals are established as part of an acquisition strategy, but the hallmark of the project manager's contribution to mission management is protecting the integrity of the competitive search through the full technology base for the best answer to a confirmed need which the project manager is responsible for meeting.

Figure I illustrates the companion concepts of mission and product management and shows the formal introduction of a project manager in accordance with revised OSD procedures. It should be noted that project management is introduced in the "middle of" mission management and continues on through product management.

Product Management. Following the competitive identification and exploration of alternative design concepts, product management begins. The first objective, demonstration and validation, may continue competitive alternatives or may be limited to a single system concept. In either case, prototype demonstrations or their equivalent are a principal objective of early product management activities. Subsequent Product Management steps include full-scale development with an emphasis on text and evaluation, production, deployment and operation.

Main Directions for Change. The series of reforms represented by OMB Circular A-109, the 1980 DOD 5000 series directives and the Congressional Budget Act of 1974 should give a visibility to Congress and to agency heads to permit them to exercise their responsibilities in a way that heretofore has not been possible. An important example of this change is the statutory requirement to utilize mission area budgeting: to present mission deficiencies and proposed responses in a coherent and understandable format for the use of agency heads, budget examiners and Congressional review.

One of the likely results of these statutory and regulatory changes will be DOD decisions to spend more time and money on early pivotal development tasks that will net savings in the larger commitments of funds that follow in programs. There should be a heavy emphasis on the front-end decision-making including especially the confirmation of needs and establishment of competitive, alternative system choice.

This signals a key change in Navy Project Management orientation. The project manager is being shifted at the outset from specifying the design of a system and controlling its development, to project management based on the test and evaluation of competing private sector design efforts. This in turn requires a new role for suppliers who must be able to demonstrate in advance that their design approaches are workable and fully meet Government needs at the lowest total cost.

A simplified and flexible decision-making process that places greater reliance on project management judgment and demonstrated hardware results and less on prescribed regulations and complicated contracts and clauses is to be used.

The combination of insights and reforms afforded by recent legislative and executive branch events now puts the Navy in the position of being able to manage systems to achieve distinctive contributions to the overall-all defense mission without compromise to required Navy force levels, systems performance or budget levels necessary to meet fully reconciled Navy needs.

MAJOR SYSTEM ACQUISITION PROCESS

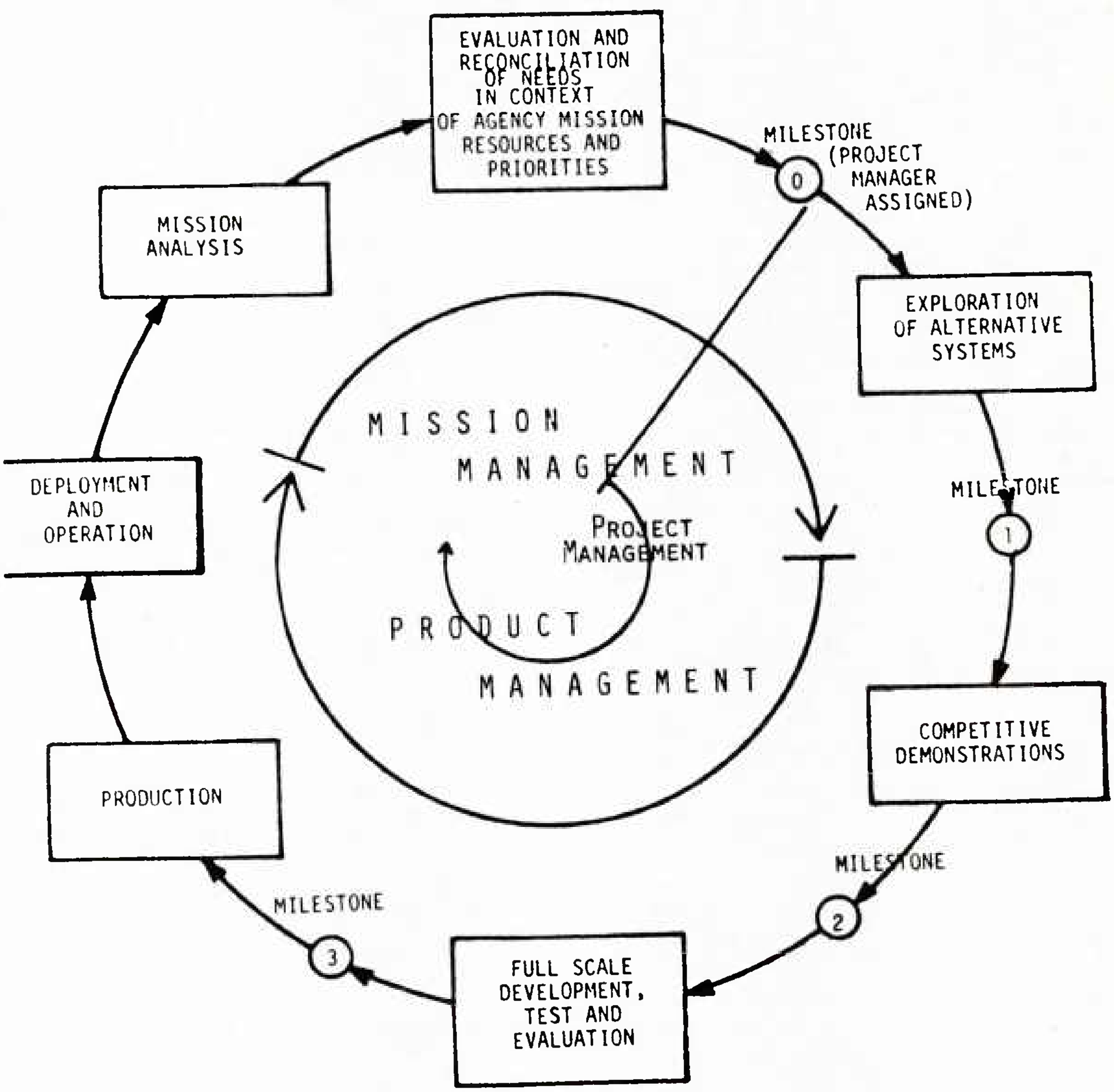

FIGURE 1

In concept, all systems are developed in response to perceived needs. System operation requirements are supposed to be determined as a result of analysis of these needs. In reality, most systems result from new scientific and technological developments, and a developer then determines what a system can do and looks around to see what needs a system can generate. There are many reasons why this is done. Usually it's the easier path to take, but it does not follow that this assures, except by chance, that the resulting system will satisfy an actual need at all or do so in a cost-effective manner. What is required in order to have a successful interaction between needs and the technology base is an initial adequate dialogue between the <u>users</u> of systems, who should identify operational needs, and <u>producers</u> of the systems, the technologists.

The crux of responsiveness to revise major system policiy lies in how well the Navy can avoid the deeply ingrained temptation to view management goals as extensions of the specialized experience and training of individual players in the decision-making process. The challenge of revised policies calls for horizons of decision making which involve entire mission areas and indeed the Navy defense mission in its totality and relationships with other service missions. To limit decision making to other than this perspective degrades the opportunity to find the best answer to mission needs and forfeits potential cost savings and schedule consideration.

More importantly, the Navy's self-interest in achieving necessary force levels to meet potential threats, the quality of performance of weapon systems and the wise use of limited resources (dollars, manpower, and materials) are all dependent on the care and restraint which is utilized in the critical "front-end, mission-need analysis".

<u>Private Sector Project Management Considerations</u>. A principal need for change should be in private sector aerospace/defense firms that traditionally have thought of themselves as having well-developed project management traditions.

There will have to be a significant "re-grouping and re-thinking" in industry in order to assume the greatly expanded responsibilities which OMB Circular A-109 "transfers" to industry.

No matter how imperfectly the decision making process was handled by the Navy in the past, regarding the evolution of a system to answer a perceived mission deficiency, this responsibility is now "transferred" to the private sector.

The question then becomes how well prepared is the private sector to accomodate these expanded responsibilities within their existing concept of "project management".

The shift in responsibility for the private sector to propose a variety of conceptual or design candidates to the customer is a new concept to industry.

The communications and decision making network which exists as a result of many current or most past industry project management efforts simply is not tuned to produce the type of decision-making and results to support their new responsibilities.

The idealized structure which now exists in the minds of private sector management or in the literature describing project management could be either "pro-active" or "reactive".

The private sector, project management structures are definitely oriented to be "reactive".

<u>Thus, nothing in the heritage or functioning of either the Navy or the private sector project management serving Navy needs approximates meeting the "new wisdom and logic" of Circular A-109 and its derivatives for mission management</u>.

<u>A Navy Model for Mission Management Decision-Making</u>
Mission analysis and the new requirement for mission management are a "user" responsibility. Hence it falls to the Office of the Chief of Naval Material generally, and specifically to the Program Planning Office (NOP090), the System Analysis Division within the Program Planning Office (NOP096), and the Office of Research Development Test and Evaluation (NOP098), to perform key mission management requirements. The relationship of "user" (Chief of Naval Operations) and the "producer" (Chief of Naval Material) is set forth in Figure 2.

The principal responsibilities within phases of acquisition management pass from CNO to CNM and back to CNO and both CNO and CNM share responsibilities throughout the process.

The concern of this paper has been focused on "mission management" and the responsibilities of CNO in this phase.

Mission management unlike the predecessor concept of program manager, cannot be the exclusive province of a single individual identified after DSARC "O" approval. The requirements for mission management, on a continuing and interactive basis, span several areas of current CNO responsibilities and CNM support. Therefore, the model for decision-making to protect the highly vulnerable integrity of mission management must be a composite of existing responsibilities with a direct reporting relationship.

CNO responsibilities for mission management begin long before DSARC "O" and continue after DSARC "O", to DSARC I. This is the most critical phase of major systems acquisition decision-making. The search for competitive alternatives, to meet mission deficiencies, occurs during this phase. The integrity of this search is an absolute measure of how well the Navy will meet its responsibilities.

Historically CNO has not been organized or oriented to perform such mission management responsibilities. For example, a broad Navy mission such as sea control, might reflect a deficiency.

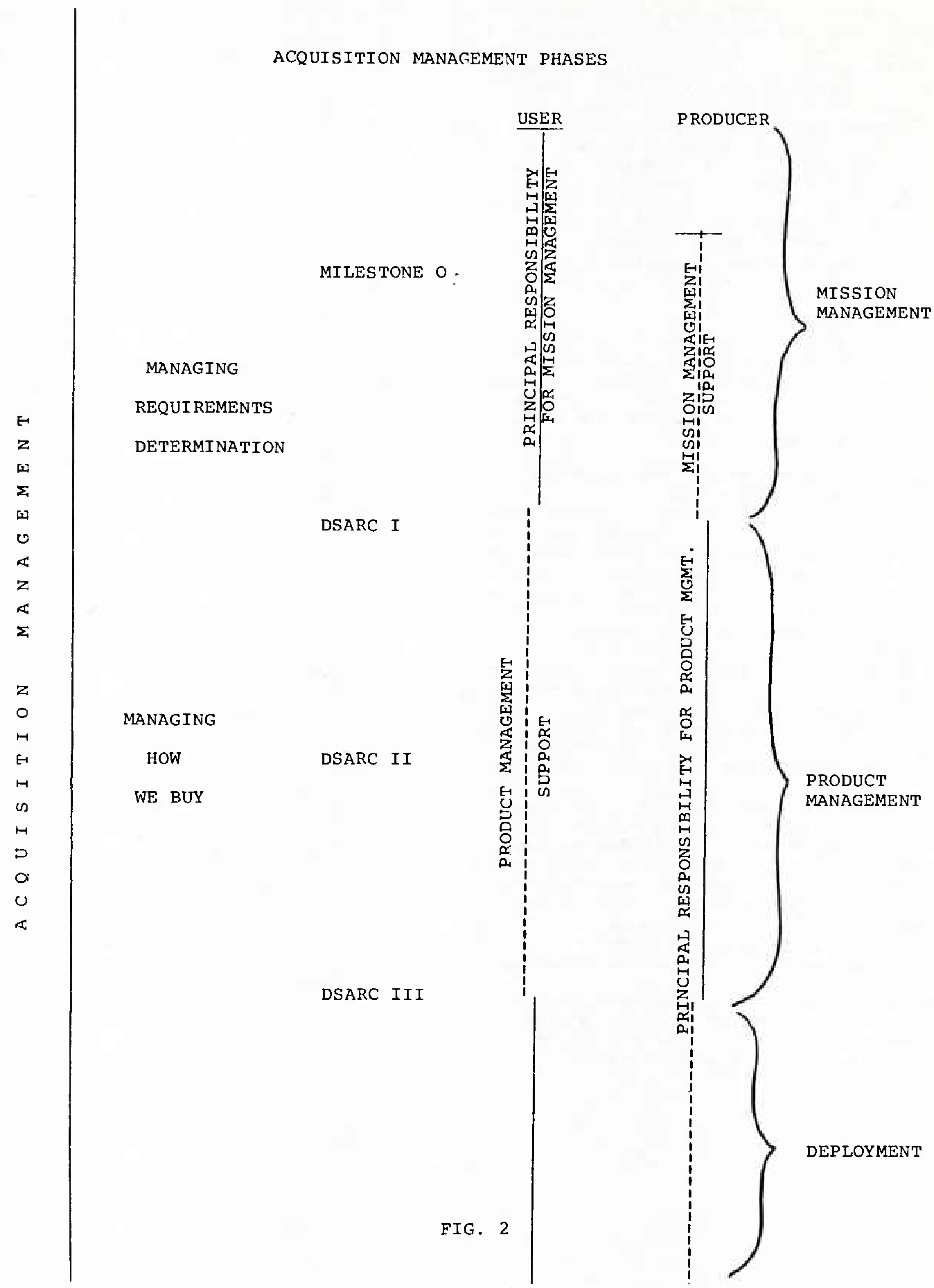
ACQUISITION MANAGEMENT
ACQUISITION MANAGEMENT PHASES
USER
PRODUCER
MILESTONE O.
PRINCIPAL RESPONSIBILITY FOR MISSION MANAGEMENT
MISSION MANAGEMENT SUPPORT
MISSION MANAGEMENT
MANAGING REQUIREMENTS DETERMINATION
DSARC I
PRODUCT MANAGEMENT SUPPORT
PRINCIPAL RESPONSIBILITY FOR PRODUCT MGMT.
MANAGING HOW WE BUY
DSARC II
PRODUCT MANAGEMENT
DSARC III
DEPLOYMENT

FIG. 2

Moreover, this deficiency could possibly be met by surface, sub-surface, air, missile or some combination of these responses. Typically a search is not made through a wide range of technologies representing competitive conceptual or design alternatives for meeting a mission deficiency. Rather, there is an immediate decision as to "who has jurisdiction" over the deficiency. Pursuit of "alternatives" is in terms of the experience and orientation of "platform sponsors" in CNO. Thus, historically, the search for competitive alternatives through the technology base is prejudiced by "human nature" by the normal experience, training, orientation and organizational assignment of key decision-makers in CNO or those in CNM whose early inputs are made to assist CNO in developing a MENS (Mission Element Needs Statement).

A pre-DSARC "0" mission management must be "user oriented", represent the broadest thinking of possibilities within a mission deficiency need and not be the captive of predetermined system solutions, specific platforms or even the Navy as the ultimate sponsoring organization!

Therefore, the organizational concept which is suggested to serve mission management decision-making, considering the "instinct" to answer questions based on individual, if limited, experience, is to create "SWAT" teams of functional specialists who may serve a number of programs within a given mission area. An entire mission area with a number of programs could be served by a relatively small number of highly competent resources representing the broadest thinking for alternatives to meet needs within a mission area. A cadre or "SWAT" team might manage several MENS (Mission Element Needs Statements) through DSARC I. The reporting levels and career impacts of such teams must take them out of a parochial relationship to usual CNO sponsors. The teams should be appointed by and report to CNO.

As of this writing there has been no Navy policy implementation which would represent the reform necessary to achieve successful mission management, although several avenues are under consideration and it is hoped that an expression may be made by the end of this calendar year (1980). There is little optimism that what will be produced will be other than a version of what now exist in terms or organizational responsibilities and platform prejudices.

Unless the Navy can command a statesman-like perspective in mission management, history will certainly repeat itself in the cost, schedule and performance problems on major Navy systems.

AN APPROACH TO QUANTIFYING THE NEED IN MISSION ELEMENT NEED STATEMENTS

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ABSTRACT

This paper discusses a top-down approach to the preparation of a Mission Element Need Statement (MENS). It proposes a functional analysis of the mission statement as a process of defining and quantifying the statement of need in the MENS. It discusses the use of a functional analysis as the means of determining measures of effectiveness for cost, schedule, and performance criteria. It shows how to define mission requirements based on threat assessments or technology advances. The functional analysis of mission statements fully supports the requirements of a MENS by specifying needed capabilities independent of the system solution proposed to meet the need. It also supports the requirements for mission budgeting and for determining the specific information required for zero-based budgeting.

PROBLEM

Recent changes in government policy have required the Department of Defense (DOD) to prepare Mission Element Need Statements (MENS) prior to initiating major system acquisition programs. DOD is experiencing difficulty in obtaining quality MENS from the services which meet all of the requirements imposed by their implementing directives.[1] This paper proposes an approach to quantifying the need in a MENS that will meet the specific requirements of the DOD directives and the spirit and intent of the congressionally initiated statutes.

BACKGROUND

Cost overruns, performance shortfalls, and schedule delays focused congressional attention on the major system acquisition process as part of the legislation forming the Commission on Government Procurement (COGP). Their 1972 report contained 149 recommendations for improving the efficiency and effectiveness of acquisition management. Two major pieces of legislation resulting from the COGP recommendations were the Budget Impoundment and Control Act of 1974 (PL 93-344), and the creation of the Office of Federal Procurement Policy (OFPP) within the Office of Management and Budget (OMB) of the Executive Office of the President (PL 93-400).

The Budget Act implemented a new fiscal year and created the Congressional Budget Office (CBO) within the legislative branch to analyze budget issues and develop fiscal alternatives. This increased professional staff provides a resource to Congress in performing their oversight responsibilities of the operation of the federal government. Another portion of the Budget Act required submission of the fiscal year 1979 Presidential Budget in a new structure, termed mission budgeting. By reviewing a budget presented in terms of agency functions, component missions and needs, and the means by which the agencies propose to meet these needs, Congress could determine where resources were required and how they were being applied to meet mission needs before they had to review in great detail what was being acquired.

Mission budgeting requires agencies to reorient their traditional line item budgets, by program, into integrated budgets, by mission. Top level policy decisions can be reviewed by Congress to determine if they comply with national policy. Early agency decisions which initiate new acquisition programs are visible in a mission budget as the means of fulfilling mission needs. This format also focuses agency attention to the relative priority of the competing mission needs in preparing their budget request.

In 1976 the OFPP issued OMB Circular A-109, a policy document on Major System Acquisitions. A-109 addresses agency missions, mission needs, and mission budgeting. The circular focuses on program initiation and the determination of mission needs as a key management decision affecting the acquisition process. A-109 suggests agency heads approve the identification and definition of mission needs, establish the relative priority of needs within their agency, and specify the magnitude of resources that may be invested in fulfilling the need. It also identifies ways of analyzing mission needs based on technology advances or deficient capabilities in existing systems.

DOD DIRECTION

Department of Defense Directives (DODDIR) 5000.1 and 5000.2, reissued on 19 March 1980, incorporate the basic concepts of OMB Circular A-109 and implement the Mission Element Need Statement (MENS) as the DOD management tool to monitor program initiation. The services, as DOD agency

components, are directed to prepare a MENS for perceived mission deficiencies and submit it to DOD as part of the Programming Phase of the Planning, Programming, and Budgeting System (PPBS) for resource allocation. These actions are specifically addressed in DODDIR 5000.2 and are summarized here for illustration.

As part of the routine planning in performing their assigned missions, the services conduct continuing analyses of their mission areas to identify deficiencies or opportunities that can be subject of a MENS. In this analysis, the services are directed to investigate identified deficiencies in existing systems, decisions to establish new capabilities, significant opportunities to reduce DOD ownership costs, and new emphasis in defense strategy. The services assess these candidate mission needs against alternatives to a new system development such as a change in doctrine, using existing commercial equipment or military systems, and modernization of existing systems. The product of this analysis should be a statement of need which is defined in terms of mission capabilities, not system characteristics, and a statement that can be used to develop a reasonable proposition to meet the need with a single system.

A MENS contains six major sections which correspond to the items identified in A-109. First, the MENS must identify the mission area or areas affected by the need, since a need may be common to more than one mission area. The mission element need is defined in this section. The second section is a summarized statement of the threat or benefits to be achieved by meeting the need. Third is a listing of existing and planned capabilities being utilized to accomplish the mission. Fourth is an assessment of the need, considered the most important part of the MENS. It evaluates the ability of existing and planned capabilities to meet the need and bases the evaluation on four factors: (1) existing capability deficiency; (2) technology exploitation; (3) force size or obsolescence; and (4) vulnerability. Fifth is a section on constraints, where key boundary conditions in meeting the need are identified, such as timing, relative priority in the mission area, logistics support and other systems engineering considerations, standardization with NATO and other DOD services, and the critical interdependencies or interfaces affecting the development of a program to meet the need. The sixth section is an estimate of the resources to be programmed and an approximate schedule for developing alternative concepts to meet the need.

After the MENS is reviewed and approved by the service, it is sent to DOD for review and approval. If the Defense Acquisition Executive plans to recommend approval of the MENS and designation of the program as a major system acquisition, he forwards the MENS to the Secretary of Defense (SECDEF). The approval of the MENS by SECDEF completes Milestone 0 of the Major System Acquisition Process, and the program enters Phase 0, Concept Exploration. The importance of this step cannot be overemphasized, for it is the MENS statement of need that will drive the conceptual development of various alternatives to meet the mission requirements and set the tone for the rest of the major system acquisition program. Approval of the MENS also means that SECDEF intends to satisfy the need by approving fiscal resources identified in the service budget request. MENS approval outside of the PPBS time frame can be funded by reprogramming actions when appropriate.

The analysis of the mission area is an excellent starting point for preparing the MENS. It is important to recognize, however, that many mission statements tend to incorporate in their definitions "solutions" to the operational capability identified. The intention of A-109 is to have the MENS defined in terms of required operational capabilities without specifying how those capabilities might be implemented.

This paper proposes and discusses a method that not only identifies the need statement of the MENS in operational terms, but also states how it might be quantified. By a thorough analysis of the mission statement, the mission need can be specifically identified, enabling the initiation of an acquisition program without specifying how the need will be met.

APPROACH

A top down approach is proposed wherein the mission statement , defined in operational terms, is analyzed to identify the functional elements of which it is constructed. The analysis proceeds from broad functional categories to subsets of specific functions required to carry out the mission. Each functional level can be quantified by some measure of effectiveness (MOE) when related to a quantifiable threat element or operational requirement. A statement of need can now be developed with appropriate MOEs and related directly to the mission requirements without specifying how the mission will be accomplished. This statement forms the basis for a MENS which can be constructed to meet the requirements of DOD directives and A-109.

METHODOLOGY

A Top Down Functional Analysis is an analytical, logically deductive logic tree process that takes broad mission statements and translates them into functional terms. A logical approach is taken to divide the mission statement into component parts, translating the "what has to be done" objectives into functions or activities to be performed. The component parts are subdivided until the functions are bounded, well defined, and easily understood portions of the mission to be performed. It is at this level that the function can be translated into technical terms and allocated to hardware, computer software programs, or operator action to be performed as part of the concept exploration phase. This step is completed when a functional diagram is available showing how the mission capabilities are divided into functions to be

performed and how each function relates to the overall mission.

The key discipline in performing this process is the need to define a complete set of functions at each level of analysis, i.e. the sum of the parts must equal the whole. If the necessary time and thought is given to this discipline in the early part of the life cycle, the resulting need statement will be independent of preconceived concepts and hardware, and it will meet the quality standards set by DOD.

The benefits of performing this analysis are first, the ability to view a complete definition of what the problem is, and second, to see how to perform the mission requirements at every level of analysis. This visibility allows the reviewer to determine what he is doing in a logical manner as well the the distinct advantage of seeing what he is not doing. If, during a review of the process, a function is introduced, it can be easily inserted and subjected to the same testing at any level without invalidating the previous work.

The development of the measures of effectiveness (MOE) for each function considers the quantified threat elements or operational requirements. The appropriate MOE can be quantified as a performance criteria that must be met to achieve the mission need. Using these criteria, the quantified functions required to fulfill the mission need can be identified.

Once the analysis is complete, it will indicate whether or not an existing capability meets mission needs. If it does not, an opportunity for the introduction of new capabilities exists. If mission needs are constrained by cost, schedule, or other factors, the performance criteria will be related to these factors. The functions to perform the mission need are derived from a logical examination of all of the functions available at every level of analysis, using the performance criteria as the basis for selection. The examination does not define how the function will be performed or integrated, but only specifies that it must be performed in meeting the mission required operational capabilities.

APPLICATION

For illustrative purposes, the Navy Sea-Based Strategic Strike mission will be analyzed and a specific need for an improved mission capability will be developed to demonstrate how the top-down methodology is applied. What is presented is not intended to be either complete or to reflect how the Navy has performed a similar analysis. It will be descriptive of the general process required to develop the statement of need and it can be used on any similar mission statement to develop the same results.

As noted earlier in this paper, the mission statement does have some solution oriented terms in it which detract from its usefulness for developing an independent statement of need for a MENS. For the purposes of this analysis, however, the mission statement will be considered as the top level requirement for the service mission area.

In order to use the mission statement it is first necessary to derive its origin and then define its terms to remove any ambiguity from the meaning of the words in the statement and to completely understand what is meant. The Navy sea-based strike mission is derived from national security interests which develop national policy and result in a national military strategy termed deterrence. If deterrence fails, then the strategy calls for the use of military force to terminate hostilities on favorable terms. These military forces form the US strategic nuclear posture. The strategic nuclear posture is based on two concepts, one of essential equivalence with the Soviet Union strategic nuclear forces, and the second of a survivable, endurable, and accurate capability to fulfill the targeting mission.

The Navy mission statement incorporates these strategies in the sea-based strike mission. It states that the sea-based strike platform must deliver strategic missile attacks against assigned targets; be able to operate at sea for extended periods as a highly reliable, survivable deterrent to a nuclear weapon attack by a foreign power and, as required, to destroy land targets with strategic nuclear armed missiles; to minimize the probability of detection by any potential threat; and to operate defensively against submarine and surface ship threats as necessary to accomplish the mission.[2]

Defining key terms in the sea-based strike mission statement will identify the required operational capabilities and functions to be performed. In selecting the key terms it is important that any term that can be interpreted be accurately defined so that the required functions can be specified in the MENS. For the purposes of this paper, only a few key terms will be defined, developed into required operational capabilities, and subsequently quantified in a statement of need.

Mission Statement Definition. The sea-based strike mission states that strategic missile strikes will be delivered against assigned targets. This constraint will not be addressed in simplifying the analysis. It is assumed that a strategic missile meeting the functional characteristics required for a sea-based platform is available. The platform description, however, has many terms that require definition in order to accurately develop required operational capabilities (ROC) and functions required to perform the mission.

A sea-based strike platform is the phrase used to describe the vehicle to be utilized in performing the strategic mission. Sea-based is an explicit description of the normal environment of this platform, as opposed to land or air. Later terms will modify this definition, but will not change its basic meaning. Strike is an offensive term, describing a military action against an enemy. Implicit in this term is the fact that it is

assumed to be a strategic missile strike, indicating that the strike is part of the US strategic nuclear posture. These terms are important in defining the ROC to be designed into the platform to perform this mission.

The next portion of the mission statement provides some amplification of the platform ROCs. It states that the platform must be reliable, survivable, and endurable in performing its mission and, it must also maintain a defensive capability. Additionally, it must minimize its detectability. It is not meaningful to specify reliable, survivable, and endurable in a mission statement unless there is some measure of effectiveness (MOE) or performance standard available to evaluate the utility of these terms. These terms have generic meanings, and it is assumed that they are all good things to have. However, they will be subject to trade-offs and quantification once some basic decisions about the functional capabilities of the platform are determined. The other two terms, defensive capability and minimum detectability, can be further developed into functional terms to express a ROC.

Functional Allocation of the ROC. In defining the functions to be performed to achieve the minimum detectability ROC, it is necessary to start at the top level requirement in the mission statement. As noted, the platform is sea-based, which defined its normal environment. The threat element would be effective in this environment, and measures of effectiveness (MOE) can be developed and quantified as performance criteria. Figure 1 shows an abbreviated functional breakdown of the sea-based strike mission statement, relative to the quantified threat.

The ROCs are shown in the first two levels of the diagram, as they define the functions to be performed in meeting the need. The functions are then allocated to show how each of the ROCs can be achieved. For this example, the functions applicable to this threat are further subdivided down to specific functions to be performed that can achieve the ROC.

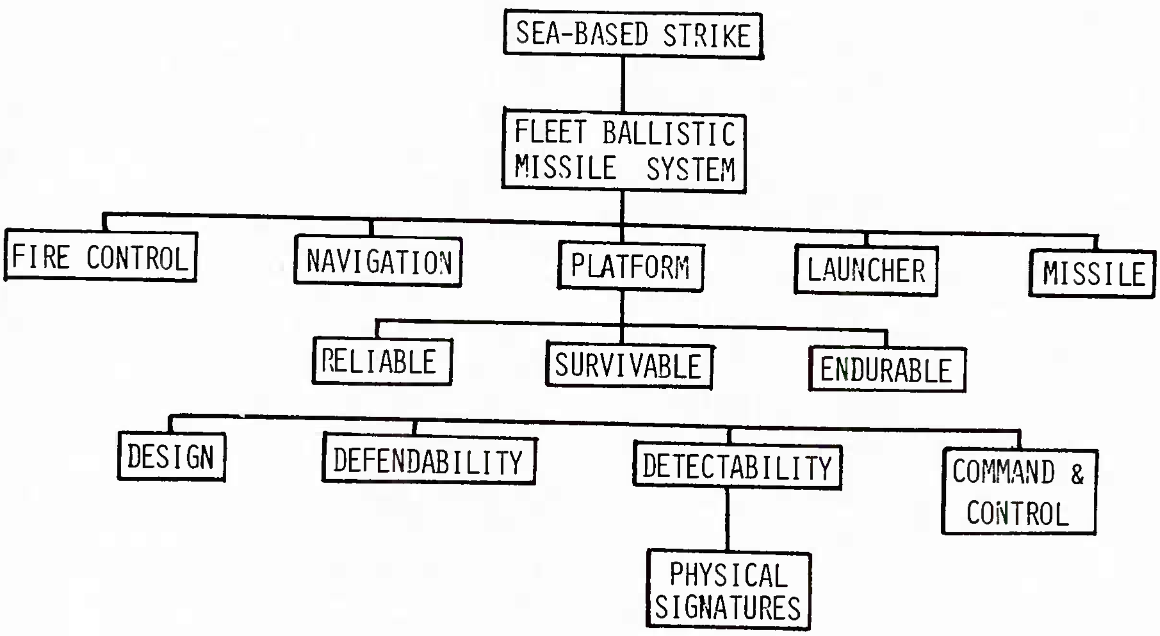

FIGURE 1.

Mission Element Need Development. For the purposes of this paper, the mission statement will be analyzed for a deficiency in the minimum detectability ROC. It is proposed that there is a quantified threat element that affects the detectability function in that the detectability of the platform is increased due to some increased capability of a potential adversary. A functional analysis is appropriate to determine the functions that are most susceptible to exploitation by the enemy and where improvements in US technology can be effectively incorporated.

It is important to recognize that what is not shown on the functional breakdown diagram may be more significant in achieving the ROC than the simple process indicates. When analyzing the entire mission statement, it may be more effective to develop a capability that will enhance the defensive ROC by eliminating the potential threat rather than designing a new detection capability to meet the specific requirements of the new threat. This possibility is explicitly not addressed in this analysis.

Measures of Effectiveness (MOE). A MOE for this function should include some measurement of alertment which can be related to time for the function being considered. To achieve this ROC the sea-based platform must remain undetected. Therefore, the platform must be able to detect the presence of a potential threat before the threat can detect the platform. Thus a good MOE would be threat detection before platform detectability, for the function being considered.

Performance Criteria. To quantify this MOE it is necessary to have a quantified intelligence estimate, which is the result of a similar analysis of the enemy capability. The theoretical detectability of a generic platform can be determined for any functional capability. These calculations will provide quantified performance criteria for developing a MENS for this mission deficiency.

MENS DEVELOPMENT

There is sufficient information available in this example to prepare a MENS that should meet the requirements of DODDIR 5000.2. This data is summarized in Table 1. The mission area has been defined as Sea-Based Strike, one part of the US strategic nuclear posture. The mission element need has been defined in functional terms as a need to improve the minimum detectability ROC as it is affected by the new threat and the technological opportunity available to reduce the sea-based platform detectability. The specific statement of need is for reduced signatures in the affected functional areas that will satisfy the MOE for detectability, and that meet the performance criteria. The benefit of obtaining this capability can be expressed in explicit terms, such as improved survivability which support the basic mission requirements.

The threat statement has been provided by the intelligence community. The quantified threat estimates used to develop performance criteria can be stated explicitly. The third section identifies existing and planned capabilities performing this function on the sea-based strike platform. Existing functional capabilities which affect the detectability MOE are included in this listing. Also, the existing sea-based strike platforms which are becoming vulnerable to the threat are part of the existing resources.

The fourth section is the assessment of the need against some specified criteria. In this example, the existing capability may not be technically sensitive to the new threat. There may be an opportunity to improve the functional capability that exists to meet the need. There may also be a situation where the existing capability is obsolete, resulting in a vulnerability due to new threat parameters that are outside the performance criteria.

The fifth section of the MENS is a statement on the constraints and boundary conditions affecting the development and deployment of a new capability meeting the need. For this example, the threat may dictate that rapid deployment of the new capability is required to ensure that the ROC is not breached and the sea-based platform remains survivable. The sixth section lists the resources being programmed to meet the need and a schedule for developing alternative technical approaches to meet the required functional capabilities in the concept exploration phase of the life cycle. The information derived from the mission analysis will be helpful in completing this section since alternative technical approaches for performing the functions have already been considered. The quantified performance criteria will help in projecting financial and schedule requirements.

CONCLUSIONS

In this paper a MENS has been developed using the process of functional analysis of the mission statement. A statement of need has been prepared in functional terms, not system requirements. The process meets the explicit requirements of DODDIR 5000.2 and fully supports the requirements for mission budgeting by detailing how a mission need will be met with the funding identified in the MENS. Zero-based budgeting is also supported since the incremental costs of meeting the mission needs are available in the analysis products to show where all mission area costs are to be applied.

By performing the functional analysis, the analyst is able to see what he is not doing in meeting mission needs - a capability not presently available in the mission analysis. Once the functional analysis of the mission area is complete, the product can be used repeatedly to generate thought for subsequent analyses of the mission area and be subjected to further analysis of projected threats at all levels of the systems design. The opportunity to review the total system capabilities will aid decision makers in determining how to apply resources and where the best inprovements can be achieved in each area without getting involved in the technical details of how the function will be performed. The logic of functional analysis will support its conclusions on any level, if the analysis is complete, and will prevent over-specifying the required operational capabilities to meet a mission need.

REFERENCES

[1] USDRE Memo of 25 JAN 1980; Subj: MENS

[2] Chief of Naval Operations, "The Fiscal Year 1980 Military Posture and Fiscal Year 1980 Budget of the United States Navy", Navy Department, (1979)

	MENS REQUIREMENTS	TOP DOWN ANALYSIS RESULTS
1.	Mission Area Identification	Based on Mission Statement
	Mission Element Need	Defined in Functional Terms Based on MOEs
2.	Threat Summary	Supplied by Intelligence Community; Quantified Threat Parameters Identified
3.	Existing and Planned Capabilities	Functional Capabilities Affecting MOE Identified
4.	Need Assessment vs Four Factors	Performance Criteria Permit Objective Assessment
5.	Constraints	Functional Requirements Subject to Trade-Off
6.	Resources and Schedule	Performance Criteria Provide Basis For Cost/Schedule

Table 1.

DOD PROFIT POLICY FOR THE 1980s

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ABSTRACT

The DoD "Weighted Guidelines" profit policy was introduced in 1964 as an objective method for Government contracting personnel to determine profit or fee negotiation objectives for negotiated contracts. There have been two major revisions to this policy; one in 1976 and another in 1980. This paper will trace the evolution of DoD profit policy, with emphasis on recent changes; review empirical data on negotiated profit rates and contractor facilities capital investment; and point out some remaining policy issues.

EVOLUTION OF PROFIT POLICY

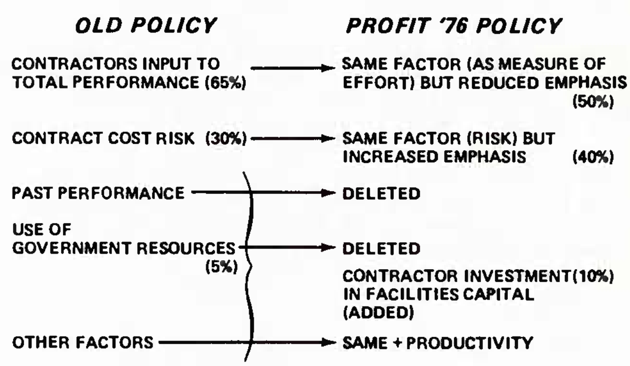
The basic DoD approach to profit objective determination is to base profit on a number of profit determining factors, with bases and numerical weight ranges designed to achieved intended results. A relatively broad potential spread in profit objectives is achieved by allowing latitude in assigning specific weights to the various profit factors and subfactors. The 1964 weighted guidelines was based on five primary factors, as depicted in figure 1. Each factor was further subdivided into subfactors with specific qualitative and quantitative evaluation criteria.

This policy was frequently criticized as being insensitive to contractor investment, and a great debate over whether profit should be viewed from a return on cost or return on investment basis raged throughout the late 1960s and early 1970s. There were numerous profit studies conducted by DoD, GAO, and private contractors. A review of these studies would disclose that it was extremely difficult to define appropriate measures of profit, as well as to obtain meaningful profit data in a useable form for policy makers.

In 1972 DoD published a new profit policy, which was designed to relate profit negotiation objectives to facilities and operating capital employed in performing individual contracts (DPC #107, 11 Dec 72). Since this policy was quite complicated, and voluntary in its application, it was seldom used, and eventually faded into oblivion. The policy did, however, establish a generally accepted method for measuring facilities capital and allocating this capital to individual contracts. This procedure eventually was incorporated into Cost Accounting Standard (CAS) 414.

Figure 1.

PROFIT '76 POLICY CHANGES



In 1976, DoD undertook a comprehensive profit study, known as Profit '76, which resulted in fundamental changes to the 12-year old weighted guidelines. These changes are summarized in figure 1 and include:

- Reduced importance of cost input to total performance;

- Increased importance of contract cost risk;

- Addition of a new factor for contractor investment in facilities capital;

- Deletion of past performance and source of resources factors; and

- Addition of a productivity reward factor.

This policy can be viewed as a compromise between the bipolar views of profit as return on cost and as return on investment, with return on cost representing about 90% and return on facilities capital investment about 10% of the average profit objective.

One unique aspect of this policy was the recognition and treatment given to facilities capital

cost of money. This imputed cost, which is really an element of profit insofar as the policy is concerned, was recognized as an allowable cost. This permits this element of profit to be reimbursed through progress payments rather than subsequent to delivery of end items.

The results of Profit '76, as measured by reported profit objectives and negotiated profit rates, have been carefully assessed by DoD. In 1979 it was concluded that:

- The return provided on facilities capital investment was not adequate for this factor to be a positive motivation for contractors to increase their facilities investment;

- Policy guidance for assigning weight to the contract cost risk factor was inadequate;

- There were too many exceptions to the manufacturing oriented profit policy; and

- There was an undesirable relationship between R&D and service contract profit levels.

After soliciting and evaluating public comments on proposed policy changes, DoD issued Defense Acquisition Circular (DAC) 76-23 on 26 February 1980. This DAC made the following profit policy changes:

- While retaining the basic structure of the manufacturing oriented policy introduced in 1976, the return provided on facilities capital investment was increased from 18 to 30 percent. This factor now accounts for about 18 percent of the average profit objective.

- Cost risk subfactor weightings for CPFF and Incentive contracts were revised.

- Policy exceptions for labor intensive R&D and service contracts were eliminated, and objective profit guidelines for these contracts were introduced.

Since this policy has been in effect for only a brief period of time, its impact remains to be measured. It is anticipated, however, that there will be a modest increase in profit levels for manufacturing contracts, although this may be offset to some degree by overall trends in facilities capital investment in relation to total cost input. Additionally, profit rates on R&D contracts are expected to increase, while profit levels on service contracts are expected to decrease.

EMPIRICAL DATA ON NEGOTIATED PROFIT RATES

Figure 2 depicts average negotiated profit rates for all DoD contracts from fiscal years 1976 through 1979. The bottom line numbers have remained relatively constant during this period. There has, however, been an overall upward trend in negotiated profit rates for the major types of contracts, as indicated by figures 3, 4, 5, and 6. This apparent contradiction has resulted from a shift in the mix of contract types, as illustrated by the following table:

Table 1.

Type of Contract	% of 1976 Dollars	% of 1979 Dollars
FPP	32.8	40.2
FPI	40.2	20.1
CPIF	10.7	22.5
CPAF	1.5	2.3
CPFF	14.8	14.9

This data indicates that there has been a significant increase in FFP and CPIF contract dollars, with a corresponding reduction in FPI dollars. These shifts occur from year to year and result from a number of factors, such as overall program maturity and emphasis placed on different types of contracts by the services.

Figure 2.

NEGOTIATED PROFIT RATES
ALL CONTRACTS

	1976	1977*	1978*	1979*	CHANGE 1976 TO 1979
ARMY	10.2%	11.2%	10.5%	9.7%	−.5%
NAVY	10.4%	10.9%	9.9%	10.3%	−.1%
AIR FORCE	10.5%	10.6%	11.0%	11.3%	+.8%
DOD AVERAGE	10.5%	10.8%	10.5%	10.7%	+ .2%

*INCLUDES COST OF MONEY
FY-1979 DATA PRELIMINARY

Figure 3.

NEGOTIATED PROFIT RATES
FIRM FIXED PRICE CONTRACTS

	1976	1977*	1978*	1979*	CHANGE 1976 TO 1979
ARMY	11.7%	12.8%	12.3%	11.8%	+ .2%
NAVY	12.2%	13.1%	12.7%	12.7%	+ .5%
AIR FORCE	11.9%	12.2%	13.2%	13.0%	+1.1%
DOD AVERAGE	12.0%	12.8%	12.9%	12.8%	+ .8%

*INCLUDES COST OF MONEY
FY-1979 DATA PRELIMINARY

Figure 4.

NEGOTIATED PROFIT RATES
FIXED PRICE INCENTIVE CONTRACTS

	1976	1977*	1978*	1979*	CHANGE 1976 TO 1979
ARMY	12.1%	12.5%	11.8%	11.3%	−.8%
NAVY	12.5%	11.3%	12.3%	13.1%	+.6%
AIR FORCE	11.2%	12.0%	11.8%	11.6%	+.4%
DOD AVERAGE	11.6%	11.8%	11.8%	11.9%	+.3%

*INCLUDES COST OF MONEY
FY-1979 DATA PRELIMINARY

Figure 5.

NEGOTIATED PROFIT RATES
COST PLUS INCENTIVE FEE CONTRACTS

	1976	1977*	1978*	1979*	CHANGE 1976 TO 1979
ARMY	8.2%	9.2%	8.2%	9.1%	+ .9%
NAVY	9.0%	8.6%	9.5%	9.1%	+ .1%
AIR FORCE	6.7%	7.3%	7.8%	9.1%	+2.4%
DOD AVERAGE	7.6%	8.2%	8.8%	9.1%	+1.5%

*INCLUDES COST OF MONEY
FY-1979 DATA PRELIMINARY

Figure 6.

NEGOTIATED PROFIT RATES
COST PLUS FIXED FEE CONTRACTS

	1976	1977*	1978*	1979*	CHANGE 1976 TO 1979
ARMY	8.3%	8.3%	8.4%	8.0%	-.3%
NAVY	6.5%	8.8%	8.1%	6.8%	+.3%
AIR FORCE	7.0%	8.4%	7.6%	7.6%	+.6%
DOD AVERAGE	6.9%	8.7%	6.8%	7.2%	+.3%

*INCLUDES COST OF MONEY
FY-1979 DATA PRELIMINARY

The composite profit data in the previous figures is a summation of four categories of basic profit data, which are:

1. Weighted guidelines used--no productivity reward.

2. Weighted guidelines used--with productivity reward.

3. Weighted guidelines not used--Facilities Capital Cost of Money (FCCOM) allowed.

4. Weighted guidelines not used--Facilities Capital Cost of Money (FCCOM) not allowed.

Aggregate data on objective and negotiated profit rates, and data for each of the above categories, are shown in figures 7, 8, 9, 10, and 11. The conclusions that can be drawn from this data are:

- Higher than average profit rates result from use of the weighted guidelines profit policy.

- Where the productivity reward factor is used, profit rates significantly higher than average are negotiated.

- The difference in profit rates for contracts excepted from the weighted guidelines policy, depending on whether FCCOM is allowed, is not clear. It could be argued that this cost is not being completely offset in profit negotiations.

Figure 7.

DOD PROFIT RATES (1979-PRELIMINARY)
ALL COMMODITIES — ALL NEGOTIATIONS
INCLUDES FACILITIES CAPITAL COST OF MONEY AND PRODUCTIVITY

CONTRACT TYPE	ARMY OBJ	ARMY NEG	NAVY OBJ	NAVY NEG	AIR FORCE OBJ	AIR FORCE NEG	DOD OBJ	DOD NEG	$ COST BASE
FFP	11.2%	11.8%	12.9%	12.7%	12.6%	13.0%	12.8%	12.9%	$6.300
FPI	10.3	11.3	13.1	13.1	11.1	11.6	11.4	11.8	3.194
CPIF	6.6	8.1	8.7	8.1	6.1	8.1	6.6	8.1	3.673
CPAF	3.4	3.4	6.2	8.5	2.0	2.0	3.8	3.7	.371
CPFF	7.3	8.0	8.7	8.6	7.3	7.8	7.0	7.2	2.300
AVERAGE	8.0%	8.7%	10.2%	10.3%	10.9%	11.3%	10.4%	10.7%	
TOTAL COST BASE									$15.906

Figure 8.

DOD PROFIT RATES (1979-PRELIMINARY)
USED WEIGHTED GUIDELINES — WITH FACILITIES CAPITAL COST OF MONEY
ALL COMMODITIES — LESS PRODUCTIVITY

CONTRACT TYPE	ARMY OBJ	ARMY NEG	NAVY OBJ	NAVY NEG	AIR FORCE OBJ	AIR FORCE NEG	DOD OBJ	DOD NEG	$ COST BASE
FFP	11.2%	11.9%	13.2%	13.0%	12.8%	12.9%	12.7%	12.7%	$4.894
FPI	10.7	12.1	11.8	11.6	11.7	12.0	11.4	11.8	2.076
CPIF	9.8	8.4	9.7	6.2	8.8	10.0	8.0	8.8	2.535
CPFF	7.8	8.7	7.8	7.8	8.1	8.2	7.7	8.1	1.270
AVERAGE	8.8%	10.9%	10.7%	10.9%	11.8%	11.9%	11.0%	11.2%	
TOTAL COST BASE									$6.480

Figure 9.

DOD PROFIT RATES (1979-PRELIMINARY)
WEIGHTED GUIDELINES NOT USED — WITH FACILITIES CAPITAL COST OF MONEY
ALL COMMODITIES

CONTRACT TYPE	ARMY OBJ	ARMY NEG	NAVY OBJ	NAVY NEG	AIR FORCE OBJ	AIR FORCE NEG	DOD OBJ	DOD NEG	$ COST BASE
FFP	12.9%	16.1%	10.7%	10.7%	12.1%	12.1%	12.0%	12.4%	$ .175
FPI	8.7	8.8	15.8	15.8	11.3	11.0	12.8	12.4	.086
CPIF	7.8	7.3	8.8	8.6	8.2	9.1	8.0	9.0	1.072
CPAF	3.7	3.9	7.7	7.8	2.8	2.8	4.7	4.8	.240
CPFF	8.0	8.6	7.6	8.1	7.8	8.2	7.6	6.3	.300
AVERAGE	7.7%	7.7%	11.9%	11.9%	9.4%	9.4%	8.8%	9.5%	
TOTAL COST BASE									$2.248

Figure 10.

DOD PROFIT RATES (1979-PRELIMINARY)
WEIGHTED GUIDELINES NOT USED — NO FACILITIES CAPITAL COST OF MONEY
ALL COMMODITIES

CONTRACT TYPE	ARMY OBJ	ARMY NEG	NAVY OBJ	NAVY NEG	AIR FORCE OBJ	AIR FORCE NEG	DOD OBJ	DOD NEG	$ COST BASE
FFP	11.2%	12.0%	8.8%	8.8%	9.7%	10.4%	9.6%	.10.4%	$1.165
FPI	7.4	8.8	7.3	7.4	10.0	10.8	8.8	10.5	.050
CPIF	8.0	7.8	8.3	9.2	8.7	9.8	8.8	8.8	.291
CPAF	2.3	2.3	1.8	2.3	1.8	1.8	1.8	1.8	.144
CPFF	6.1	6.0	5.0	4.6	8.8	7.0	9.7	8.9	.900
AVERAGE	9.1%	9.9%	8.8%	5.4%	9.9%	9.1%	7.9%	8.2%	
TOTAL COST BASE									$2.611

Figure 11.

DOD PROFIT RATES (1979-PRELIMINARY)
USED WEIGHTED GUIDELINES — WITH FACILITIES CAPITAL COST OF MONEY
ALL COMMODITIES — WITH PRODUCTIVITY

CONTRACT TYPE	NAVY OBJ	NAVY NEG	AIR FORCE OBJ	AIR FORCE NEG	DOD OBJ	DOD NEG	$ COST BASE
FFP	—	—	14.5%	16.8%	14.5%	16.8%	$1.053
FPI	—	—	11.2	12.8	11.2	12.5	.401
CPFF	8.5	8.5	—	—	8.5	5.5	.002
AVERAGE	8.5%	5.5%	13.6%	16.0%	13.6%	16.0%	
TOTAL COST BASE							$1.286

INVESTMENT TRENDS IN THE DEFENSE SECTOR

DoD recently sponsored a study designed to measure facilities capital investment trends since 1976. This study examined facilities capital investment as computed and reported under CAS 414 for 62 contractor profit centers significantly engaged in DoD business. The data in figure 12 indicates there is a general increase in facilities capital investment when absolute dollar levels of investment are considered, yet when this same investment is viewed in relation to total cost input, as shown in figure 13, investment, at best, seems to only holding its own with respect to increases in the total cost input base. Figure 14 indicates that defense oriented profit centers are still largely characterized by relatively low levels of investment in relation to cost inputs.

Figure 12.

CHANGE IN FACILITIES CAPITAL INVESTMENT
(Absolute Dollars)
1977 - 1980

	PROFIT CENTERS
INCREASE	55
DECREASE	4
NO SIGNIFICANT CHANGE	3
TOTAL PROFIT CENTERS	62

Figure 13.

CHANGE IN FACILITIES CAPITAL INVESTMENT
(As Percentage of Total Cost Input)
1977 -1980

	PROFIT CENTERS
INCREASE	29
DECREASE	24
NO SIGNIFICANT CHANGE	9
TOTAL PROFIT CENTERS	62

Figure 14.

FACILTIES CAPITAL INVESTMENT
(As Percentage of Total Cost Input)
1980

PERCENTAGE RANGE	NUMBER
0-5	11
6-10	23
11-15	20
16-20	3
21-25	4
26-30	
31-35	
36-40	
41-45	1
TOTAL PROFIT CENTERS	62

An attempt was made to relate investment to defense versus commercial cost inputs in these profit centers, and the results are shown in figure 15. This data seems to indicate that defense investment may be growing at a slightly greater rate than that associated with commercial business, but the rate remains uncomfortably close to zero growth. We intend to annually update and increase the coverage of this data base in order to provide a means of assessing this important component of profit policy.

Figure 15.

CHANGES IN FACILITIES CAPITAL INVESTMENT
1977 - 1980

	77-78	78-79	79-80	ANNUALIZED 77-80
TOTAL FACILITIES CAPITAL INVESTMENT	5.5%	23.4%	28.9%	18.8%
TOTAL COST INPUT	15.4	21.7	16.8	17.9
RATIO OF TOTAL FACILITIES CAPITAL INVESTMENT TO TOTAL COST INPUT	−8.6	1.6	10.4	.8
TOTAL DEFENSE FACILITIES CAPITAL INVESTMENT	2.8	15.7	23.0	13.5
TOTAL DEFENSE COST INPUT	6.5	8.7	12.7	9.2
RATIO OF DEFENSE FACILITIES CAPITAL INVESTMENT TO DEFENSE COST INPUT	−3.8	6.5	9.2	3.9

REMAINING POLICY ISSUES

There remains a number of profit policy issues under active consideration by DoD. These include:

- Appropriate revisions to the productivity reward profit factor. This factor has not been used to the extent originally envisioned, and we are seeking ways to simplify the criteria for its use. The problem with productivity is in many respects similar to the problem that existed with capital investment ten years ago--there is no generally accepted definition and means of measurement.

- The profit factor for independent development needs to be clarified. At present, there seems to be considerable confusion of this factor with IR&D, when its intent is to provide additional profit when acquiring items that were independently developed.

- Actions need to be taken to minimize the inertia in the system with respect to profit policies. Contract changes and modifications adding new work and ceiling priced options subsequently negotiated at the same profit level as the basic contract will blunt the thrust of recent profit policy changes unless the current policy is made applicable to these types of contractual actions.

IMPLICATIONS FOR THE 1980S

The most recent changes to the DoD profit policy have resulted in at least 95 percent of negotiated DoD contracts being subject to an objective policy for determining the reasonableness of profit negotiation objectives. Current economic conditions are such that there is a reasonable doubt as to whether the return provided on facilities capital investment is adequate to motivate additional contractor investment. The investment decision making process is complex and is influenced by many factors other than the rate of return. It is also characterized by a lengthy period between investment planning and the time when an investment is brought "on line." DoD will continue to evaluate its profit policy against intended results and will probably make additional changes where necessary and appropriate. It is clear, however, that investment will be the key to profitability during this period, and that contractors can expect DoD to continue to emphasize investment and productivity in return for higher profit rates on defense contracts.

CONCEPTS AND APPROACHES TO PROJECT COST AND SCHEDULE INTEGRATION AND MANAGEMENT WITHIN DOE

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ABSTRACT

Discussion of the concepts and approaches to project cost and schedule integration and management at the Department of Energy. An overview of the evolution of the Project Management System, basic concepts and principle elements are described. The DOE's implementation of the Cost and Schedule Control Systems Criteria is described in detail.

FIGURE 1

This is the Department of Energy organization. The left side of the chart is the regulatory and information side of the organization. The middle of the chart includes six Assistant Secretaries and the Director of Energy Research. This is the outlay side of the Department. Since DOE's inception in 1977 we have been defining and evolving the concepts and principles which will govern the management of DOE's outlay programs and projects.

DEPARTMENT OF ENERGY

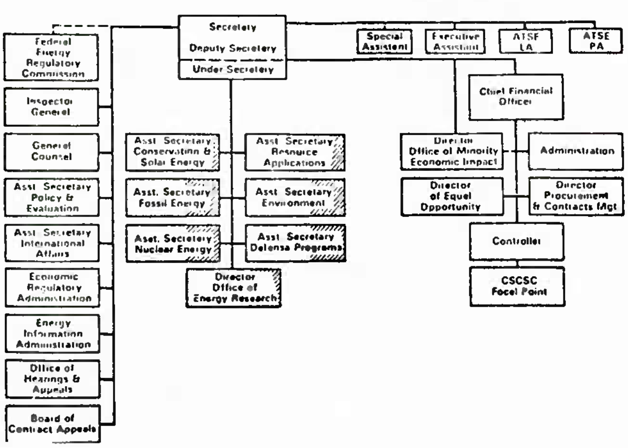


FIGURE 2

The DOE Program and Project Management System establishes the basic concepts which govern the formulation, approval and execution of DOE's programs and projects.

PROGRAM AND PROJECT MANAGEMENT SYSTEM

A Disciplined, Systematic Approach to Program/Project Formulation, Approval and Execution.

Principal Concepts

- Categorization of Work Effort
- Phased Approval of Projects
- Baselining of Work Effort
- Energy Systems Acquisition Advisory Board
- Visibility and Accountability
- Decentralization of Project Management

FIGURE 3

Under the umbrella of the Program and Project Management System a series of recent related Departmental policy statements have been finalized which define and formalize the system or project, acquisition process; providing detailed implementing guidance to DOE's program and project managers and staff. Within a climate of fiscal restraint and limited resources the increasing cost, complexity and national importance of DOE's projects have made it imperative that DOE improve its methods of identifying, managing and controlling to facilitate bringing projects in on time and within costs.

PROGRAM AND PROJECT MANAGEMENT SYSTEM

Policy Documentation

- DOE Order 5700.1, Major System Acquisitions
- DOE Order 5700.2, Independent Cost Estimating
- DOE Order 5700.3, Major System Acquisition Procedures
- DOE Order 5700.4, Project Management System Manual (Draft)
- DOE Order 4240.1, Designation of DOE Major Systems Acquisitions
- DOE Order 4210.2, Business Strategy Groups
- DOE Order 1330.2, Uniform Contract Reporting System
- DOE Order 2250.1, Cost and Schedule Control Systems Criteria for Contract Performance Measurement
- DOE Order _____, Planning, Programming and Budgeting System

FIGURE 4

Project management within DOE follows the percepts of OMB Circular A-109, Major System Acquisitions, with its emphasis on fulfillment of mission need, competition, trade-offs, strong checks and balances and development of an acquisition strategy. DOE makes a strong differentiation between a program and a project. A program is an organized set of activities directed toward a common purpose, objective or goal undertaken or proposed by DOE in order to carry out responsibilities assigned to it. It is characterized by a plan of action designed to accomplish a definite objective. It defines the means of accomplishments, particularly in quantitative terms, with respect to manpower, materials and facilities requirements. Program management is located at Headquarters with major responsibilities for providing the overall integration, direction and resources for the programmatic effort. A project is a major subset of a program. Most of DOE's projects involve the building of facilities or plants for the conduct of research or proving the feasibility of an energy technology or processing of special materials (such as nuclear materials, fuels and wastes). Project management is usually located in the field, which is normally where the project will be, with commensurate authority and responsibility for project execution.

A set of related and formal documents govern project acquisition. DOE uses the Mission Need Statement for approval of the identified need and system initiation. The Project Charter is the document issued by the cognizant Assistant Secretary or Director of Energy Research which establishes the responsible managing office, a project manager, his mission, authority and functions and describes, in general, the project management guidelines and parameters. The Project Plan serves as the overall project baseline in terms of cost, schedule and technical objectives and is essentially summary in nature, being oriented toward use by senior management officials while the Project Management Plan sets forth the Project Manager's plans, systems and techniques to be utilized in his/her management of the project. The Energy System Acquisition Advisory Board serves as an advisory board to the Decision Authority at each Key Decision point in the acquisition process. It provides a single forum for a discussion of issues and alternatives and is designed to assure coordinated, objective senior level management advice.

PROGRAM AND PROJECT MANAGEMENT SYSTEM

- A System Governed by OMB Circular A-109, Major System Acquisitions Precepts
- Program versus Project
  - *Program* is an Organized Set of Activities Directed Toward a Common Purpose, Objective or Goal Undertaken or Proposed by DOE in Order to Carry Out its Responsibilities.
  - *Project* is a Major Endeavor within a Program with Firmly Scheduled Milestones; Prescribed Performance Requirements; Prescribed Costs; and Close Management and Control.
- Documentation
  - Mission Need Statement
  - Project Charter
  - Project Plan
  - Project Management Plan
- Energy System Acquisition Advisory Board (ESAAB)

FIGURE 5

The Cost and Schedule Control Systems Criteria concept as implemented through DOE Order 2250.1 provides an improved tool for achieving better cost, schedule and technical control of DOE's large complex projects through application on contracts. Decisions to implement this concept were made only after careful study and consideration of potential costs and benefits. In late 1974 the Reactor Development and Demonstration Division of one of DOE's predecessor agencies, the Energy Research and Development Administration (ERDA), initiated the Criteria approach, called the Performance Measurement System, to improve visibility into and control of projects facing unforeseen and escalating cost estimates. The concept is similar to that being used in DOD.

At the same time the need to establish a standard (uniform) set of contract reporting requirements was apparent. The Uniform Contractor Reporting Guidelines (UCRG) were developed in ERDA and are used in DOE to meet this need. The standarized CSCSC Cost Performance Reports are a subset of the UCRG.

DOE CSCSC POLICY

- Improve Project Management Methods and Techniques Through
  - Improved Visibility of Contractor Cost and Schedule Performance
  - Receipt of Reliable Data to Support Responsible Decision-Making
- Use Criteria Approach to Accomplish these Objectives

FIGURE 6

Experience with the Criteria approach proved to be beneficial and cost effective resulting in a DOE wide policy in September 1979 whose objectives reinforce the concepts of the Program and Project Management System.

CSCSC POLICY OBJECTIVES

1. Portray Time-Phased Budgets and Forecast Estimated Costs to Completion
2. Measure Work Progress
3. Identify Problems and Analyze Variances and Trends
4. Relate Accomplishments and Problems to Forecasts
5. Report Contract Performance Information
6. Provide Summary Level Data
7. Facilitate Effective Management Decisions
8. Define and Organize Contract Work
9. Assure Sound Contractor Management Control Systems
10. Establish Cost, Schedule and Technical Baselines
11. Earned Value is Basis for Performance Measurement
12. Assure Status and Trend Data are Valid and Traceable
13. Reduce Proliferation of Standards, Systems and Reporting Requirements
14. Consistently Apply Criteria on Contracts
15. Promote Criteria Implementation by Contractors
16. Consistency with Other Government Agency Implementations

FIGURE 7

Implementation of the Criteria approach and use of the Earned Value concept has been an evolving, educational process for DOE. We look at the Earned Value Concept as a method of assessing progress in terms of resources. We can indicate our status of having "earned" so much planned resource "value". If we plan a job to be accomplished with a hundred hours of effort and we can determine that we are physically fifty percent complete, we can say we have earned fifty hours of value, regardless of the number of hours actually expended in reaching that level or the number of hours required to finish. Earned Value itself is the specific value of the current progress and since all resources can usually be reduced to dollars, Earned Value is usually stated in dollars.

Earned Value must be the product of disciplined cost and schedule control systems. To insure that Earned Value is the product of disciplined management control systems, we allow contractors to use their existing systems which meet their management needs, provided the systems can also meet certain Criteria necessary to assure that they objectively plan, earn and properly report Earned Value. This is the Criteria approach.

EARNED VALUE CONCEPT AND THE CRITERIA APPROACH

Earned Value

- The Periodic, Consistent, and Objective Measurement of Work Performed in Terms of the Budget Planned for that Work.

Cost and Schedule Control Systems Criteria

- The Characteristics that a Contractor's Internal Management Control Systems must Possess to assure Effective Planning and Control of Contract Work, Costs and Schedules.

FIGURE 8

Potential benefits accrue to both DOE and contractor management from the use of the Criteria approach. In reviewing the actual working of the contractor's management systems, DOE personnel gain a good working knowledge of the contractor's organization, systems operation and procedures, and the mechanics of report preparation. The standarization and discipline inherent in the Criteria approach provide for and require more detailed and timely planning of the contract work. Performance is being measured against a formal, contract-related baseline rather than against a contractor's internal operating plan which may be different from the contractual commitment. Finally, Criteria implementation enhances overall project management by promoting the integration and effectiveness of the financial, schedule and technical control systems.

Contractors, in turn, gain improved and earlier visibility into systems operations and work progress, accomplish more detailed work planning, better communication internally and with DOE and increased cost and schedule awareness at all functional levels of management.

BENEFITS OF THE CRITERIA APPROACH

Government

- Working Knowledge of Organization and Systems
- Detailed and Timely Planning of Contract Work
- Formal, Contract-related Performance Measurement
- Integration of Financial, Schedule and Technical Control Systems

Contractors

- Improved Visibility
- Better Communication
- Increased Cost and Schedule Awareness

FIGURE 9

Dollar thresholds and considerations such as project urgency, special problems, application on existing contracts, criticality of subcontractors and type of contract are factors which should be weighed in each contract application.

THRESHOLDS & CONSIDERATIONS FOR CRITERIA IMPLEMENTATION

Thresholds:

Estimated Cost	— Over $50 Million — Full
	— $2 to $50 Million — Modified
Estimated Time	— One Year or More

Considerations:

Project Urgency	— National Interest
Special Problems	— High Risks
Existing Contracts	— Subject to Negotiation
Subcontracts	— By Agreement Between PM and Prime, According to Criticality
Type of Contract	— Normally Not Applicable to FFP & FFP With Escalation

FIGURE 10

In addition, the diversity in DOE's projects and contracts is recognized in our policy in the evolution of two types of Criteria implementation, full and modified.

PROJECTS AND CONTRACTS FOR CRITERIA IMPLEMENTATION

Types of Projects

- Engineering
- Research
- Development
- Demonstration

Types of Contracts

- Architect and Engineering
- Construction
- Production
- Operations and Maintenance

FIGURE 11

The primary difference between full and modified implementation is in the degree of latitude which DOE exercises in specifying Criteria requirements and in the subsequent determination of contractor complaince. Modified implementation introduces flexibility into the implementation process to accommodate contract factors such as lesser dollar value, risk, criticality, or prominence. Satisfactory demonstration of implementation under full CSCSC results in a Certificate of Validation issued by the Controller. Under modified implementation the contractor's systems are accepted by the project office.

FULL VERSUS MODIFIED CRITERIA IMPLEMENTATION

- Degree of Latitude in Specifying Criteria and Determining Compliance
- Flexible Implementation Process
- Full Implementation — Validation
- Modified Implementation — Acceptance

FIGURE 12

The Office of the Controller has the responsibility for developing the DOE policy for the Criteria approach and, as the focal point for its use and application, monitors implementation and resolves significant problems encountered in systems review and surveillance.

Full implementation is required for all now (after March 31, 1980) Major System Acquisitions while application on other projects whether full or modified is by program manager direction.

APPROACH

- Controller is Central Point of Contact for Implementation
- Full Implementation Required on All Projects Designated as Major System Acquisitions
- Full or Modified Implementation May be Directed for Other Projects

FIGURE 13

Recognizing the diversity in projects and contracts has resulted in a flexible approach where the Controller is providing overall guidance and assuring consistency in the role of Review Director with project management having the lead role in application and systems review and surveillance with participation by other offices, such as the Cognizant Auditor, Contracting Officer and Program Office as appropriate.

APPROACH

- Determine Applicability and Extent of Implementation on Contract-By-Contract Basis
- Project Management Participation in Implementation Activities
- The Requirement Will Span Contract Life
- Cost Performance Reports are in DOE's Uniform Contractor Reporting Guidelines

FIGURE 14

Shown here are several of the actions that are being taken to facilitate implementation of the Criteria approach.

DOE ACTIONS TO FACILITATE IMPLEMENTATION

- Structure Project
- Identify Need for Technique Early
- Introduce Flexibility
- Provide Adequate Contractual Coverage
- Conduct On-Site Reviews and Surveillance
- Integrate Guidance

FIGURE 15

Since the first CSCSC review activity as the Fast Flux Text Facility in Richland, Washington in February 1976 there have been seventeen validations or acceptances by DOE or the Energy Research and Development Administration. This viewgraph and the next show some of the typical applications of the Criteria approach in DOE.

DOE IMPLEMENTATION REPRESENTATIVE PROJECTS

Nuclear Energy
- Clinch River Breeder Reactor Plant
- Fast Flux Test Facility
- New Waste Calcining Facility
- Fuel Storage Facility
- *• Waste Isolation Pilot Plant

Fossil Energy
- *• Low/Medium BTU Fuel Gas Demonstration Plant A
- *• Solvent Refined Coal Demonstration Plants
- *• High BTU Synthetic Pipeline Gas Demonstration Plants

FIGURE 16

We are moving ahead at DOE with the Criteria approach. It is increasingly seen by program and project managers and DOE's top management as an improved tool for achieving better cost and schedule control.

DOE IMPLEMENTATION REPRESENTATIVE PROJECTS

Energy Research
- *• Tokamak Fusion Test Reactor
- *• Fusion Materials Irradiation Test Facility
- *• Mirror Fusion Test Facility

Defense Programs
- *• High Energy Laser Facility (NOVA)
- *• Fluorinel Dissolution Process & Fuel Receiving Improvements

Resource Applications
- *• Strategic Petroleum Reserve
- *• Enriched Uranium Production Facilities

We are in the process of developing detailed guidance documentation on the Criteria approach. Five CSCSC guides are planned, two of which are now available. If you should like these or copies of DOE's CSCSC policy please contact me at (202) 252-4057.

A WORKING C/SCS FOR NAVAL SHIPBUILDING

G. GRAHAM WHIPPLE
GROUP VICE PRESIDENT

LOCKHEED CORPORATION

ABSTRACT

The production of U.S. Naval ships, which involves a blend of conventional shop manufacturing practices with elements more akin to construction, presents a unique challenge for Cost/Schedule Control System operation under DOD Instruction 7000.2. This paper describes a system developed by the Lockheed Shipbuilding and Construction Company, validated by the Naval Sea Systems Command in 1976, and well proven in some five years of use.

Upon the award of the first two "LAND" class submarine tenders to LSCC (Lockheed Shipbuilding and Construction Co.) in November 1974, the criteria of Department of Defense Instruction 7000.2 for Cost/Schedule Control Systems was imposed.

The company reaction to this contract software requirement was initially mixed. LSCC had not participated in U.S. Navy new construction for several years, and was still nursing its wounds (along with other shipbuilders) from the naval construction fiasco of the 1960's. While it was felt that a better system for construction statusing and forecasting could be beneficial, the memories of a profusion of acronymic customer invented and autocratically imposed so-called management systems of the prior decade were still fresh in our minds. In retrospect, it is pleasing to report that the DOD 7000.2 concept which only sets criteria and encourages the contractor to invent and use his own workable system, along with a very mature administrative approach by NAVSEA (Naval Sea Systems Command) rather rapidly overcame our initial skepticism and got the job moving.

The first column of Figure 1 lists the mandatory criteria for all DODI 7000.2 systems without deference to program or product peculiarities. The working system objectives and features highlighted in Fig. 1 are also of general import. The system objective can be even more succinctly stated as "How are we doing compared to where we ought to be, and how will it all end?" To continually provide the answer to that question, the system must feature:

a. Visibility - show us the facts as clearly as possible.

b. Responsiveness - let the facts be fresh information.

c. Earned value - what did we get for what we paid.

d. Integration of Cost and Schedules - recognition that "when" continually interrelates with "how much".

e. Responsibility Definition - who has control of the resources producing the results.

f. Forecasting accuracy - what we can reasonably predict from current returns.

It is worth noting that the criteria, the system objectives and features represent a communal interest to NAVSEA and the shipbuilder. Furthermore, both have an interest in using the information generated by the system beyond the instant contract or program. The "spiral of

C/SCS CRITERIA	SYSTEM OBJECTIVES	SYSTEM FEATURES
• Organization • Planning & Budgeting • Accounting • Analysis • Revisions	• Performance Visibility • Focus For Comparing Current & Projected With Baseline • Accurate & Timely Forecasts	• Visibility • Responsiveness • Earned Value • Integration Of Cost & Schedules • Responsibility Definition • Forecasting Accuracy

Figure 1 — SYSTEM CRITERIA, OBJECTIVES & FEATURES

refinement" shown in Fig. 2 expresses this in contractor terms, but NAVSEA no doubt has its own verbs to label the cycle. We both want and need to continually refine our estimating base for future work.

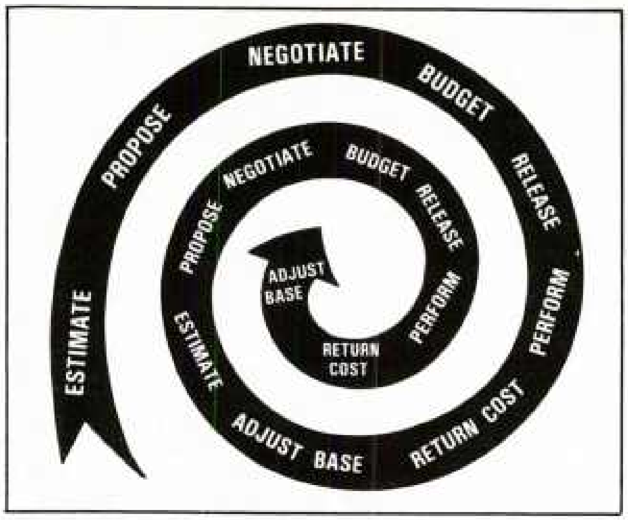


Fig. 2 — PRODUCT FINANCIAL CYCLE

Fig. 3 highlights the distinctive elements which characterize naval ship construction, and Fig. 4 gives us gross descriptions of the product. To gain a better appreciation of the ship, consider that each one has:

a. Well over an acre of steel in each through deck.

b. 34 miles of completed pipe runs.

c. 120 miles of electrical conductor.

d. 1500 foundation-mounted pieces of machinery.

e. 12 elevators.

f. 4,000 feet of monorail trackage.

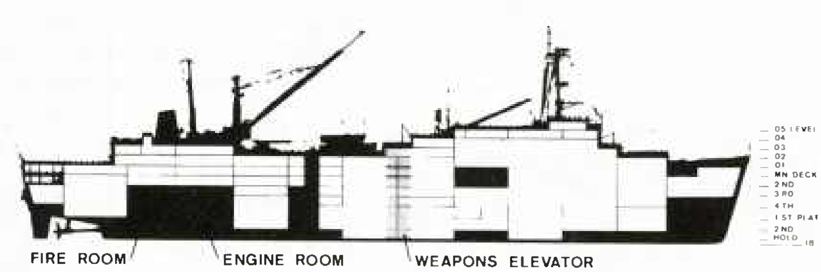
g. 27,000 pieces of furniture,
and for the Yuletide,
a partridge in a pear tree!

- Over Four Year Construction Span
- 5 Million Manhour Integrated Effort
- Multiplicity Of Crafts
- Blend Of Construction & Manufacturing
- Over 50,000 Line Item Bill Of Material
- Prime Contractor Management > 90% Of Supply Structure
- Incremental Testing To Support Finished Product Performance Test

Fig. 3 — NATURE OF PROGRAM/PRODUCT

NAVSEA visualizes the construction of the ship in a very neat manner, the SWBS (Ship Work Breakdown Structure) better known as the "Nine-Way Breakdown". This is an engineering definition of the ship, proceeding from generic levels thru major systems and subsystems to detail pieces. As shown in Fig. 5, the various SWBS levels are assigned standard cost code numbers for cost accumulation to the configuration breakdown.

While this may be a most useful system for NAVSEA to look at costs of individual ships, make comparisons among various ships, and estimate cost of new ships, it's not very helpful for running the shipbuilders day-to-day operations. Let's look at the particular Hardware Subsystem detailed in Fig. 5, the firemain system, Cost Code 5060. About two years will elapse from the time the first pipe assembly is complete in the Pipe Shop until the last pipe run of the subsystem is installed in the ship and ready for system test. During the fabrication and installation of pipe for this subsystem, a few dozen other pipe dominated subsystems are concurrently being manufactured and installed. Individual subsystem completion is much less of a driver than the necessity to work all pipe regardless of function in a given area as the ship grows incrementally on the shipway and at the outfitting pier. This not only provides for best use of the pipe craft labor, but is even more driven by required sequences of other, and equally important, non-pipe installations in the same, and often constricted areas, of the ship.



SHIPS CHARACTERISTICS

LENGTH	644 FEET
BEAM	85 FEET
FULL LOAD DISPLACEMENT	23,000 TONS
TOTAL COMPLEMENT	1,351 PERSONS
DECK LEVELS	13
COMPARTMENTS AND SPACES	913 (PLUS 107 TANKS)

Fig. 4 — AS-39 LAND CLASS SUBMARINE TENDER

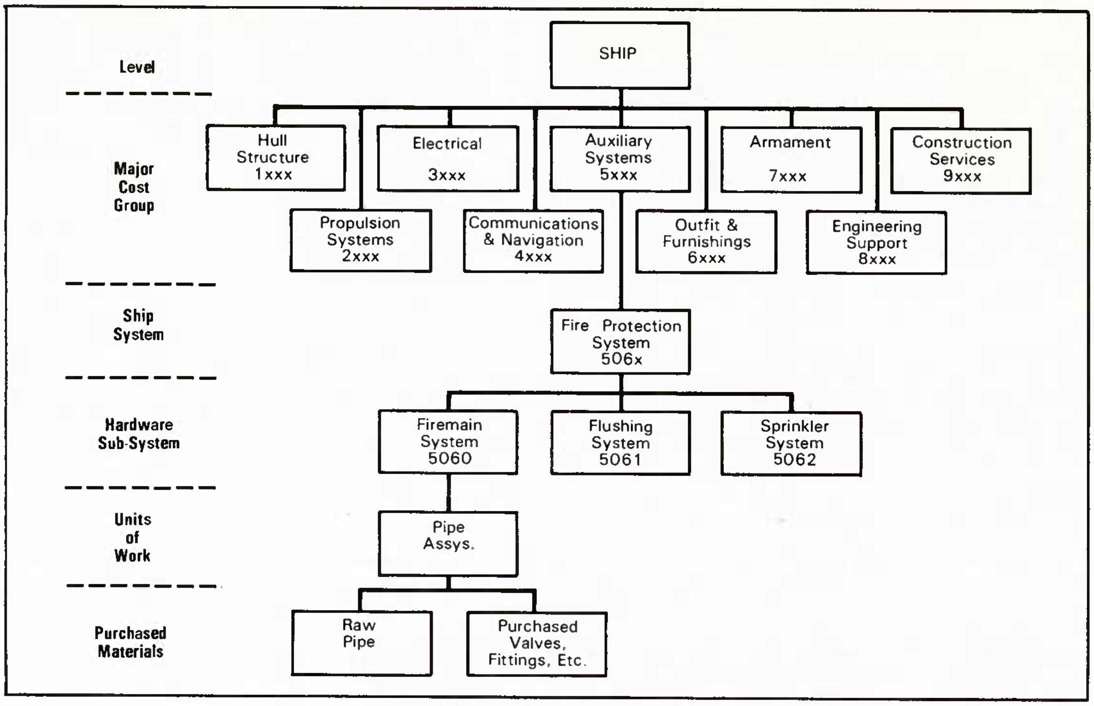


Fig. 5 — SHIPWORK BREAKDOWN STRUCTURE — SWBS

So we have a huge and complicated article to build, the customer needs the cost gathered up in one manner, and the shipbuilder for good reason has to do it in another. Since we differently define the beast by how we lay on our hands, it is perhaps apt to remember the six blind men of Hindustan who approached the elephant. There's only one good way to resolve the problem - find a least common denominator - see Fig. 6!

The "small bite" approach is the basis of our whole system. Fig. 7 summarizes how we divide our particular pachyderm into 180,000 bite size pieces. A price (budget) is assigned to each piece, and rate of dining (schedule) is applied to similar bites. Actual consumption is compared to the menu to determine earned value.

To some, 180,000 may seem like a large number, but reference to Fig. 8 seems to support that it's rather reasonable. We complete about 900 bites a week per ship, worth about 25 manhours each, and each NAVSEA SWBS cost code is supported by about 100 performance building blocks.

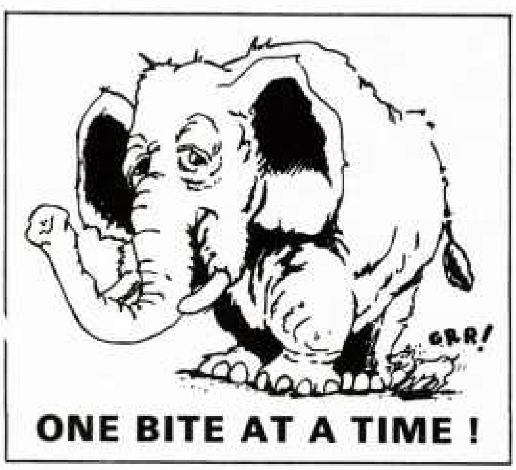


Fig. 6 — HOW TO DIGEST AN ELEPHANT

ELEMENTS		WORK UNIT	UNITS COUNTED
Steel Shops —	Ship, Slab, Ship (8500 Tons Net)	Tons	25,500
	Plate - Foundations, Misc. & Outfitting Steel	Pieces	7,380
	Lead - Panels	Pieces	947
	Pipe - Regular	Ass'y.	8,541
	- NSF	Ass'y.	495
	Machine	Pieces	1,178
	Sheet Metal	Ass'y.	24,272
	Label Plate (Includes Installation)	Oesign Area Kit	777
Ship —	Foundations	Pieces	1,701
	Steel	Pieces	4,484
	Shielded Assemblies	Pieces	323
	Pipe - Regular	Equiv. Ass'y.	19,130
	- NSF	Equiv. Ass'y.	608
	Machinery	Load Equiv.	9,752
	Electrical	125' Equiv.	21,706
	Sheet Metal	Ass'y.	25,408
	Joiner	Pieces	21,377
	Scalers	Sequences	2,592
	Painters	Sequences	3,824

Fig. 7 — CONSTRUCTION — 180,000 BITES

About 20% of the direct labor hours going into the shp (Fig. 9) are non "hands-on". Of these, Systems Test and Trials is covered as measured work, just like the 80% craft labor. The remainder is time related Level of Effort. On a subsequent new ship class, the LSD-41 Landing Ship Dock, we are extending our system validation to cover original release engineering. There are clear opportunities to convert some presently LOE where a "countable" output exists for measurement, such as Material Planning/Control and Planning and Scheduling.

Fig. 10 is a block diagram of the principal inputs and outputs of the system. It should be noted that although our "arithmetic" is performed with IBM-370 level hardware (which performs much other work) the system software is simple and a low capacity computer would handily perform the job on a stand-alone basis.

The "fine-tune" system element is manhours, and rightly so, since shipbuiding is extremely labor intensive. Besides, the whole management structure right down to a working leadman in charge of eight people thoroughly understands it. Therefore, the basic weekly cost input is in direct manhours, which is also the easiest way since the same hours must be accounted for in payroll, which also allows us to accumulate labor dollars by extending the hours by the direct labor rate paid.

Manhours expended and production unit count are weekly inputs. Material commitments and bookings are also reported weekly. Since practically all material activity is a one-time contract commitment, material detail by SWBS cost code and estimates to complete are performed on a monthly basis. Overhead applications are applied to monthly output reports, and adjusted annually (for the shipbuilders overhead year) although more frequent adjustments are made if of amounts significant to total contract cost. All output reports show comparisons to planned budget and schedule.

$$\frac{\cong \text{180,000 BITES}}{\cong \text{200 WEEKS CONSTRUCTION SPAN}} \cong \text{900 BITES/WEEK}$$

$$\frac{\text{4,200,000 CONSTRUCTION M/H}}{\cong \text{180,000 BITES}} \cong \text{25 MAN HOURS/BITE}$$

$$\frac{\cong \text{180,000 BITES}}{\text{1830 WBS CODES}} \cong \text{100 BITES PER WBS CODE}$$

Fig. 8 — BITE DIGESTION RATE

MEASURED — Systems Tests And Trials (360 Items)

LEVEL OF EFFORT — Engineering
Lofting
Quality Assurance
Tool Rooms/Cribs
Materiel Planning/Control
Production Control
Master Scheduling
Planning And Scheduling
Production Salaried Supervision
Other Production Administration
Other Support - Program Office
Reproduction
Program Cost Analysis

Fig. 9 — NON-CONSTRUCTION ELEMENTS

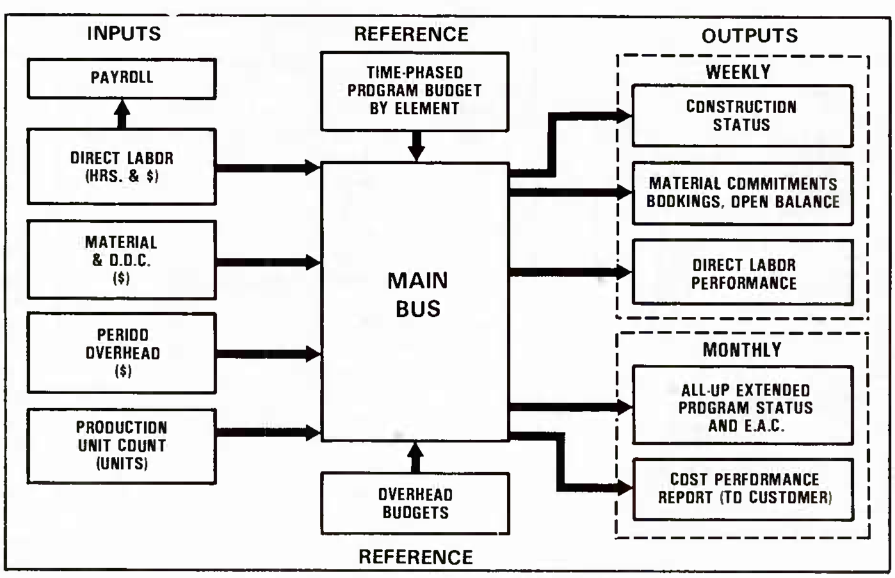


Fig. 10 — INPUTS & OUTPUTS

SUBMARINE TENDER CONSTRUCTION STATUS			VESSEL AS-41						WEEK ENDING 4-25-80	
ELEMENT	UNIT OF MEASURE	QUANTITY PER SHIP	THIS WEEK		CUMULATIVE				MANHOURS/UNIT	
			SCHEDULE	ACTUAL	SCHEDULE	ACTUAL	AHEAD (BEHIND)	TO GO	BUDGET DATED	TO DATE
SHOPS									9/20/78	
Plate – Prop. Foundations	Each	32	–	–	Compl.	–	–	0	72.3	58.7
Plate – Aux. Foundations	Each	1,669	17	2	1,241	1,658	417	11	14.3	15.1
Plate – Misc. Steel	Pieces	470	–	–	Compl.	–	–	0	26.6	28.1
Plate – Outfitting Steel	Pieces	5,209	35	3	4,688	5,031	343	178	9.5	9.1
Lead Shielding	Pieces	947	–	1	947	947	–	–	32.7	32.5
Pipe	Assy.	8,541	60	8	7,220	8,026	806	515	12.9	12.1
NSF Pipe	Assy.	495	3	–	425	492	67	3	60.6	37.6
Machine	Pieces	1,178	8	0	1,104	992	(112)	186	19.0	20.2
Sheet Metal	Assy.	24,272	115	74	21,589	23,174	1,585	1,098	3.6	4.5

Fig. 11 — BUDGET SCHEDULE PERFORMANCE

The internal "how goes it" reports are available to all levels of management in identical format no later than the third working day following the end of a week's work with the close of the day shift on Friday. Fig. 11 is the weekly "Budget/Schedule Performance" covering each measured element; the sheet shown is for Shops - similar ones are available for structural steel and outfitting. Fig. 12 "Direct Labor Performance" covers about 50 line items describing the whole direct labor input and Performance Ratio (Earned Value) for the entire job.

DIRECT LABOR PERFORMANCE	PERFORMANCE SUMMARY	LAST WEEK	THIS WEEK	SHIP/PROJECT	WEEK ENDING
	% TOTAL HOURS SPENT	66.22%	66.84%	AS-41	4-25-80
	% COMPL. TOTAL CONTRACT	65.66%	66.27%		

ELEMENT	MANNING EQUIVALENT		TOTAL PROJECT BUDGET	PROJECT TO DATE			FOR THE WEEK		
	BUD.	ACT		HOURS EXPENDED	HOURS EARNED	PERF. RATIO	HOURS EXPENDED	HOURS EARNED	PERF. RATIO
SHIP — PIPE	140.2	108.0	656,159	356,160	421,107	1.18	4,322	5,524	1.28
TOTAL	480.8	425.3	1,941,722	1,061,783	1,172,018	1.10	17,018	18,237	1.07
QUALITY ASSURANCE	27.4	28.2	171,820	105,640	112,521	1.07	1,127	1,095	0.97
TOTAL NON-PRODUCTION	174.6	157.6	1,190,738	780,256	829,909	1.06	6,301	6,967	1.11
TOTAL	909.6	818.3	5,320,396	3,563,851	3,572,465	1.00	32,728	30,700	0.94

Fig. 12 — DIRECT LABOR PERFORMANCE

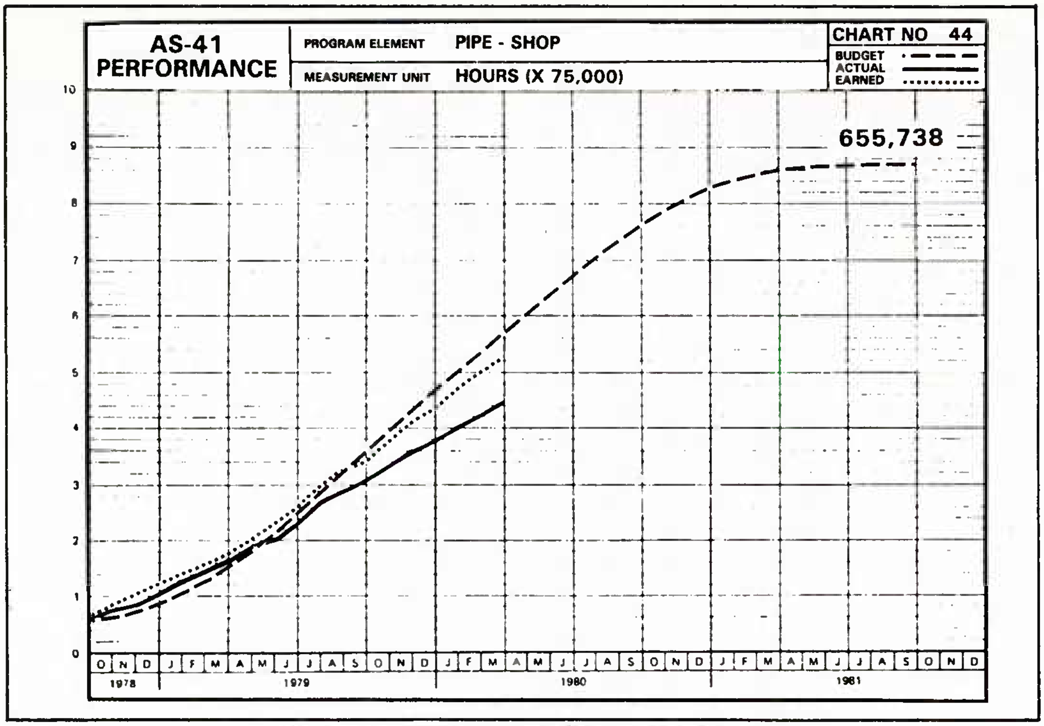


Fig. 13 — COST/SCHEDULE SUMMARY

Fig. 13 is a sample of the "Cost/Schedule Summary" provided monthly both internally and to NAVSEA for every labor element. This is the classic DODI 7000.2 display which integrates both cost and schedule performance and trend against the reference PVWS curve.

It is apparent that the system is heavily oriented to the use of cumulative cost versus time. One of the very useful fallouts of this approach can be seen in Fig. 14. For similar elements it is very easy to plot activities on log-log paper to produce a continuous labor progress curve which graphically extends to man hours at completion.

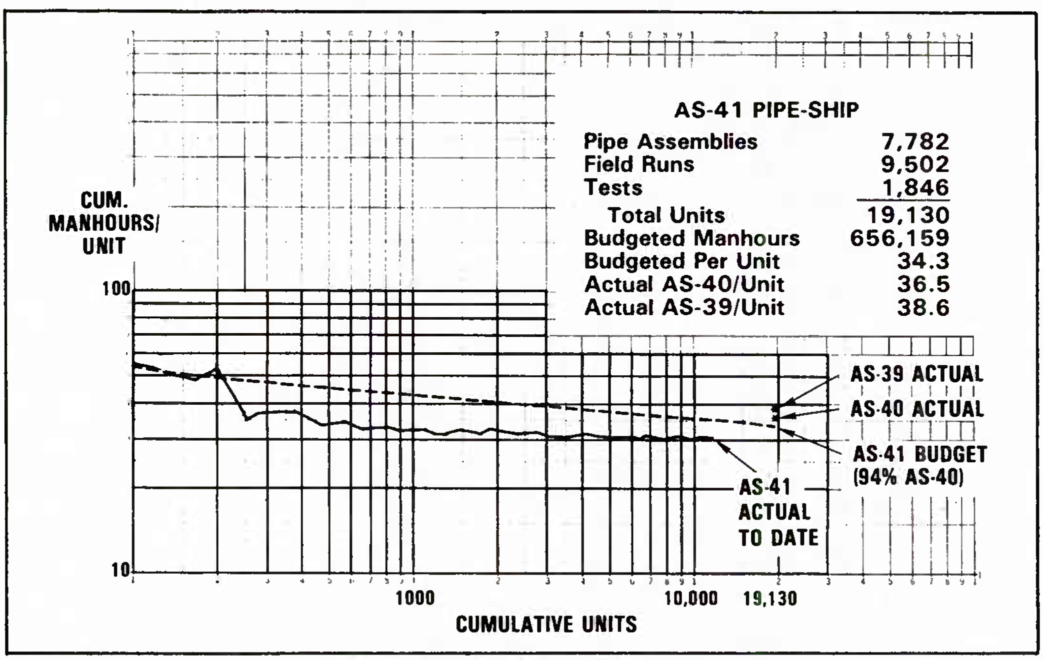


Fig. 14 — LABOR PROGRESS PLOT

In summary, Fig. 15 shows how we've come out in relation to our objectives set down over five years ago. We have indeed designed a system appropriate to the peculiar nature of Naval shipbuilding which fully meets the DODI 7000.2 criteria, and that in fact works. The system, as is true of all systems, doesn't control cost and schedules - men do that - but they have been provided a powerful tool to manage their work.

PERFORMANCE VISIBILITY	• High Visibility • Identical Numbers To All Management Levels • Weekly Reports — 3 M Days After Week Close
FOCUS FOR COMPARING CURRENT & PROJECTED WITH BASELINE	• Baseline Is Control Reference • Identical Comparison Units • Cost/Schedule Status & Progress In Common Terms
ACCURATE AND TIMELY FORECASTS	• EAC Labor Hours Weekly - All Elements • Material & Overhead Monthly - Program • Estimated Forecast Accuracy

AT COMPLETION % OF	LEAD SHIP	FOLLOW SHIPS
25	± 10%	± 3%
50	± 5%	± 2%
75	± 2%	+ 1%

Fig. 15 — OBJECTIVE ATTAINMENT

THE USE OF SPARES OPTIMIZATION MODELS IN INITIAL PROVISIONING

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ABSTRACT

The fundamental problem in initial provisioning is to find a strategy for acquiring spares that will provide a level of weapon-system availability during the system's early life that is, in some sense, acceptable for the least expected total cost. Spares optimization models take a system view, i.e., they determine the relative worth versus cost of each of a system's components and find the optimal mix of spares for any specified level of availability. The DoD Standard Initial Provisioning (SIP) policy, on the other hand, takes an item-oriented view based on a demand-based stockage criterion alone. Clearly, any provisioning technique that does not take item cost explicitly into account will never be as cost-effective, in general, as one that does. In short, the SIP policy actively inhibits the intelligent conservatism in initial provisioning investment it seeks to achieve.

INTRODUCTION

The fundamental problem in initial provisioning (IP) is to find a strategy for acquiring spares that will provide a level of weapon-system availability that is, in some sense, acceptable for the least total cost. (We will use the terms availability, supply availability, end-item availability, and weapon-system availability interchangeably here; we mean the probability that an end item, such as a tank or aircraft, selected at random, is not waiting for a component to be repaired or be shipped to it.) In the IP context, the concepts of availability and total cost are substantially more complicated than in the peacetime, steady-state world of spares replenishment.

In the steady-state situation, availability is typically computed at a point in time based on several important assumptions including (1) stationarity in the probability distribution of the number of components of each type in resupply and (2) stability in the inventory of end items and the operating program for some period of time ahead of the point in time for which the availability is computed. Clearly, these assumptions (and others we shall discuss later) are violated in the IP context. IP is done for the typical weapon system at a time when the end-item inventory is changing, engineering changes are being made, item characteristics (already a matter of considerable uncertainty) are changing, and, perhaps, deployment plans and other system-level characteristics are still changing. Thus, although the fundamental IP problem has characteristics similar to the spares replenishment problem, it is dramatically more difficult. The concept of availability takes on a new dimension, time. It is important in the IP context to think of availability as a function of time, just as end-item inventory size and item characteristics can be viewed as functions of time.

The concept of total cost is also more complicated because it, too, has additional dimensions. Component unit prices are among the things about which uncertainty exists. Furthermore, obsolescence costs induced by engineering changes tend to be incurred in the IP context much more frequently than in the replenishment situation. Thus, it is really total expected cost that we wish to consider in the IP problem where the expectation recognizes possible futures involving penalty costs.

The need to achieve availability levels that will support training and readiness requirements tends to drive one in the direction of buying substantial quantities of spares early; however, the penalty costs for eventual excesses, obsolescence, or retrofits tend to dissuade one from early investment. The problem is to determine how we can be conservative with respect to spares investments early in the life of a weapon system and still provide adequate numbers of available end items.

The statement of the IP problem as that of providing an acceptable level of availability for the least expected total cost suggests the use of a spares optimization model that finds the least-cost mix of spares for a specified availability.

SOME STOCKAGE POLICY ANALYSIS

A Simple Numerical Example. We begin by considering a simple numerical example designed to provide some intuition about how a spares optimization model takes advantage of the heterogeneous characteristics of components to compute cost-effective stockage policies.

In this example we consider a two-echelon inventory system consisting of a depot and three bases. There are 30 end items (aircraft, say, or tanks) at each base. Each end item consists of 10 components. All of the components have exactly the same characteristics except for their unit costs. The item characteristics and unit costs are shown in Tables 2-1, and 2-2, following.

Table 2-1

ITEM CHARACTERISTICS	
Base Daily Demand Rate	0.10
NRTS (not repairable this station) Rate	0.50
Pooled Base Daily Demand Rate	0.30
Depot Daily Demand Rate	0.15
Base Repair Time	5 days
Depot Repair Time	45 days
Order-and-Ship Time	5 days

Table 2-2

UNIT COSTS	
ITEM	COST
1	$ 500
2	1,000
3	2,000
4	4,000
5	8,000
6	16,000
7	32,000
8	64,000
9	128,000
10	256,000

The inventory system operates according to a continuous-review (S-1,S) policy; it is described graphically in Figures 2-1 and 2-2.

The expected number of each component in resupply, i.e., the item pipeline quantity, is 8.25.

The relationship between the end-item availability and spares investment cost computed by the spares optimization model is depicted graphically in Figure 2-3. This curve is typical of many such availability-vs.-cost curves despite the simplistic character of this example.

A stockage policy of special interest is that of buying eight of each component. Such a policy emulates to some extent the Standard Initial Provisioning (SIP) Policy of the DoD. For our simple example, it represents buying a pipeline quantity of each item with no provision for safety stock. For this case, we compute the availability associated with the optimal distribution of the items among the depot and bases. In Figure 2-3, the point designated "SIP" represents the availability and cost that would result from buying a pipeline's worth (8) of each item. The cost is $4,092,000; the resulting availability is 84.6 percent. This policy can readily be compared to the availability-vs.-cost curve computed by the spares optimization model; however, two points on that curve are of special interest for comparative purposes, one where the availability is the same as for the "SIP" policy, the other where the cost is the same. The comparison is made directly in Table 2-3.

TABLE 2-3

"SIP" VS. OPTIMIZATION

ITEM	UNIT COST	"SIP"	OPTIMIZATION	
1	500	8	22	19
2	1,000	8	21	17
3	2,000	8	20	17
4	4,000	8	19	16
5	8,000	8	17	14
6	16,000	8	16	13
7	32,000	8	13	11
8	64,000	8	11	9
9	128,000	8	9	4
10	256,000	8	5	0
	COST $	4,092,000	4,092,000	1,884,500
	AVAIL %	84.6	95.0	84.6

As this example shows, for the same budget of $4,092,000, an optimal policy yields an increase in availability from 0.846 to 0.950, an average of 9.36 more available end items; furthermore, an optimal policy will produce 0.846 availability for $1,884,500, less than half the cost of the "SIP" policy.

One can easily see from this straightforward comparison the superiority of an optimized policy; however, the computations underlying this example assume that all item and system characteristics are known with certainty and that steady-state conditions apply.

Dealing With Uncertainty. In our example, the pooled base daily demand rate of each of the 10 items was 0.3. Our computations of availability assumed that this intensity of demand was a known constant and that demands were generated randomly over time with this specified intensity, i.e., the number of demands observed in a time period of arbitrary length, say t days, followed a Poisson distribution with parameter 0.3t.

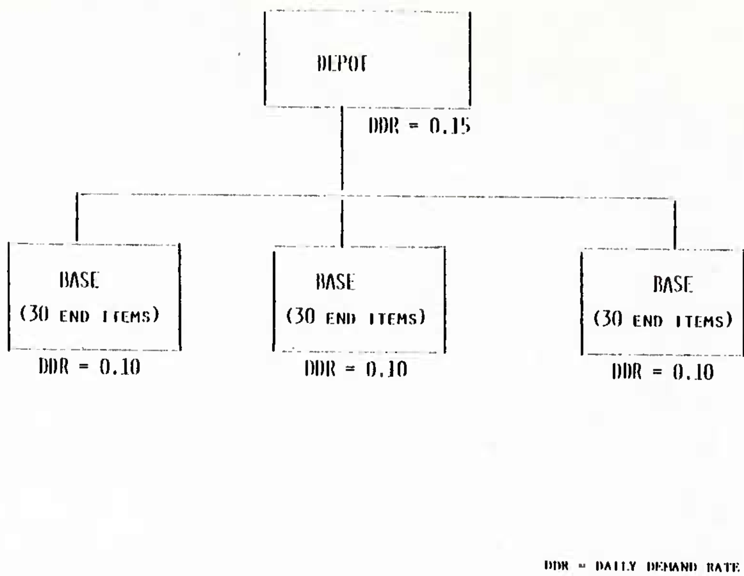

Figure 2-1. A Simple Numerical Example

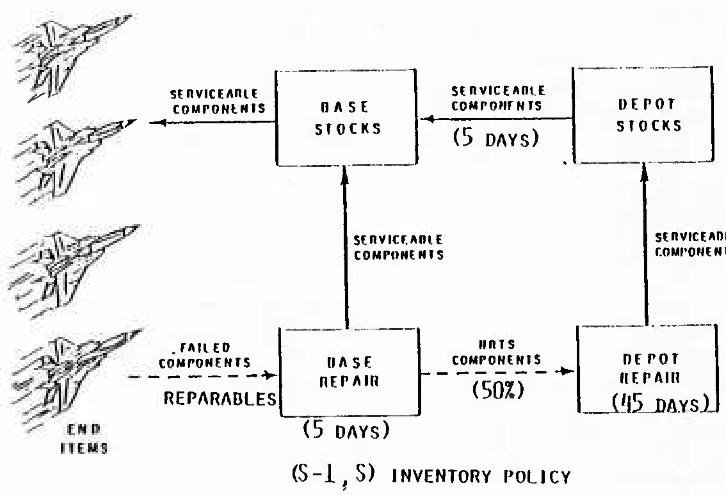

Figure 2-2. Flow of Components

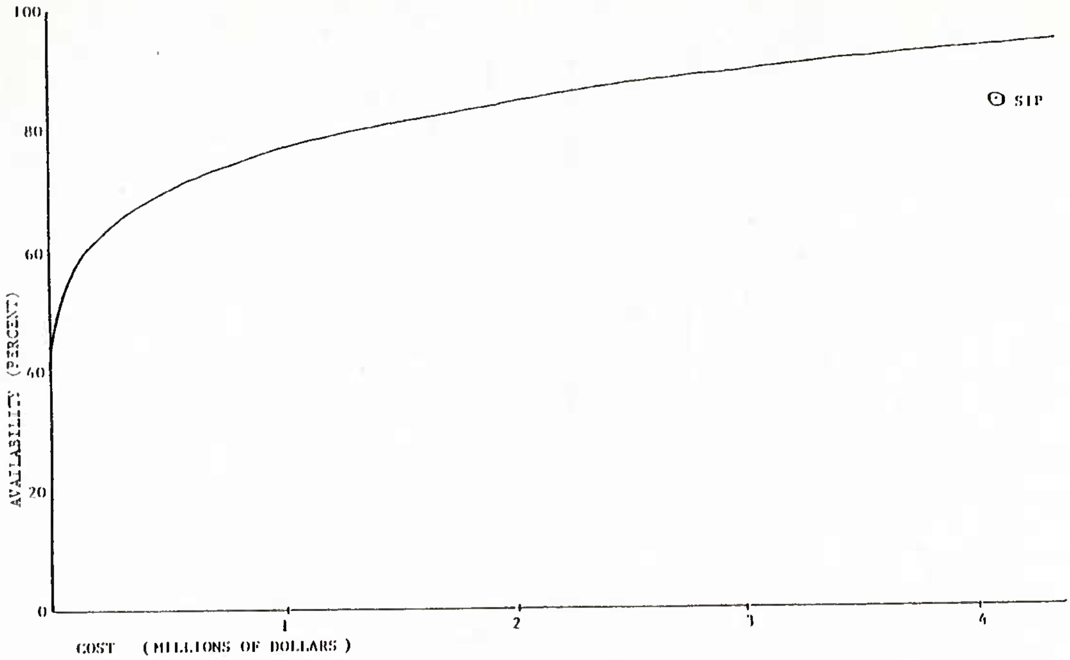

Figure 2-3. Availability vs. Cost

Suppose, now, we are uncertain about that demand rate because item and weapon-system characteristics are not fully known and we are faced with unreliable data. We will characterize our uncertainty about the demand rate by modelling it as a random variable with the probability density function shown in Figure 2-4.

We now recompute the availability-vs.-cost curve taking explicit account of our uncertainty about demand. The result is shown in Figure 2-5. For comparative purposes, the curve of Figure 2-3 is reproduced in Figure 2-5 as a dashed line.

The relationship between these two curves can tell us something about the worth of reliable demand estimates because the less uncertainty we have about the demand rate, the less we need to invest if we expect to achieve a specified level of availability. In this simple example, if we specified an expected availability rate of 90 percent, it would require about $4 million in the face of our uncertainty but only about $3 million if the demand rate were known. Thus, the expected value of perfect information about the demand rate in this particular case is about $1 million. Given the right kind of representation of uncertainty about item characteristics, it is feasible to compute the expected value of additional operational test and evaluation (OT&E) of specified length or end-item operation.

It is interesting to examine two particular points on this availability-vs.-cost curve, again for comparative purposes, the one with an availability equal to the "SIP" availability (0.846) and the one with the same investment, $4,092,000. These two new stockage policies are shown in Table 2-4 with the stockage policies examined previously.

A Note On Robustness. Table 2-4 contains, for each stockage policy, two availability rates. The availability rates identified as "Estimated Availability" for the "SIP" policy and policies A and B were computed as though the demand rates were known constants. For policies C and D they were computed as though the demand rates were random variables with the distribution shown in Figure 2-4.

The availability rates identified as "Actual Availability" are the expected availability rates that result from selecting randomly a demand rate for each component from the distribution in Figure 2-4. In other words, they are the expected availability rates that eventuate in the face of uncertainty. It is important to note that the "SIP" policy is the least robust of those examined here.

Table 2-4. SIP vs. Alternative Policies

ITEM	UNIT COST ($000)	SIP	QUANTITIES BY POLICY A	B	C	D
1	.5	8	19	20	33	36
2	1.0	8	18	20	30	34
3	2.0	8	17	19	27	30
4	4.0	8	16	18	24	27
5	8.0	8	14	16	21	24
6	16.0	8	13	15	18	20
7	32.0	8	11	14	15	17
8	64.0	8	9	11	10	14
9	128.0	8	4	9	6	9
10	256.0	8	0	5	0	3
COST($)		4,092,000	1,885,500	4,092,000	2,540,500	4,092,000
ESTIMATED AVAILABILITY (%)		84.6	84.6	94.1	84.6	90.3
ACTUAL AVAILABILITY (%)		76.2	80.0	88.9	84.6	90.3

Wholesale Vs. Retail: A Lesson On Togetherness. For every stockage policy examined so far, the availability has been computed based on the stock-level distribution among the depot and bases that minimized expected base-level backorders, i.e., that maximized end-item availability. In order to provide some basis for at least an intuitive understanding of the importance of distribution we present several alternative distributions for the simplistic weapon system we have been examining where we have a total of eight of each component, i.e., the policy that emulates a SIP policy.

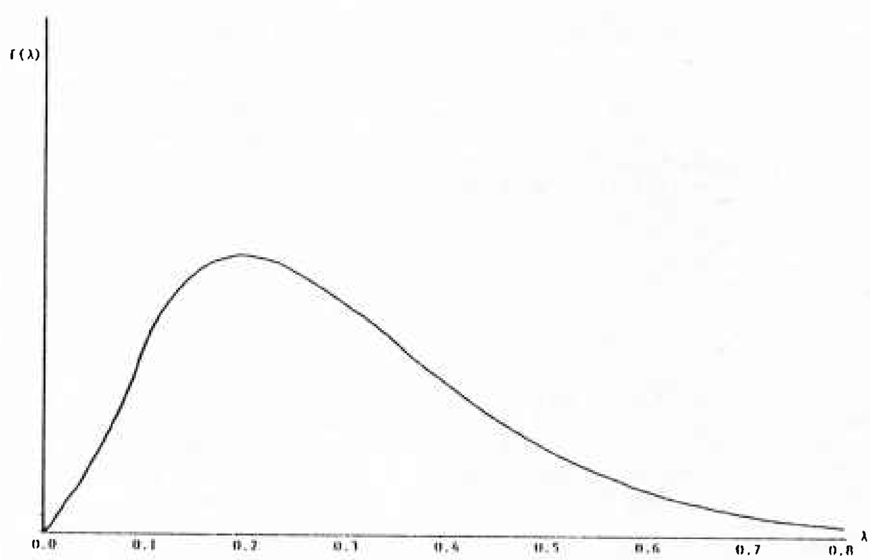

Figure 2-4. A Model of Uncertainty

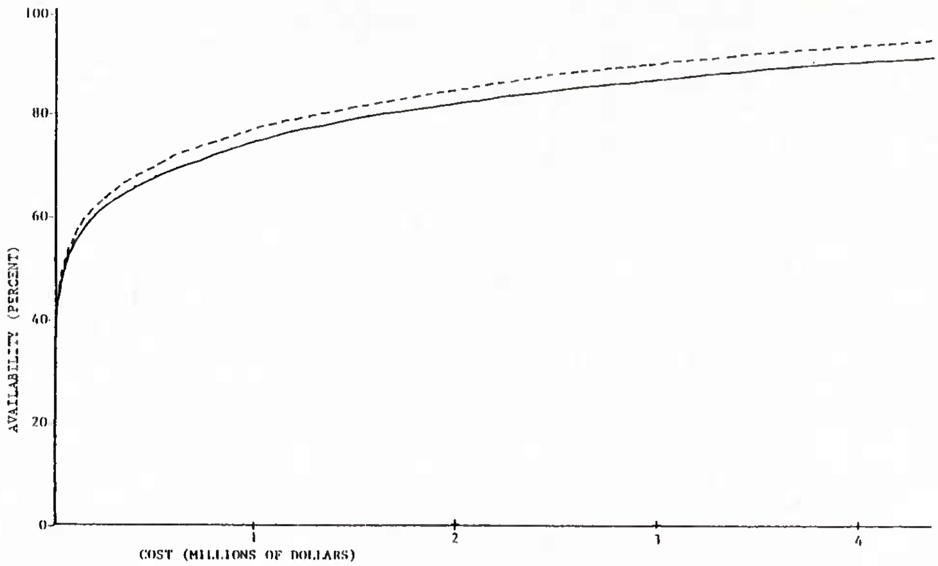

Figure 2-5. Availability of Cost When the Demand Rate is a Random Variable

We first discuss the cases where all of the stock is put at a single echelon much in the spirit of RIMSTOP (although RIMSTOP specifies a single <u>retail</u> echelon). In the first case, all of the stock is allocated to the depot, in the second case all to the bases. (See Figures 2-6 and 2-7.)

Expected Backorders = 2.05
Depot 8 Availability = 79.5%

Bases 0 0 0

Figure 2-6. Allocation To The Depot

Expected Backorders = 2.12
Depot 0 Availability = 78.8%

Bases 3 3 2

Figure 2-7. Allocation To The Bases

Both of these alternatives yield roughly 79 percent availability. Another alternative is represented by partitioning the stock levels in the same proportion as the depot and base pipeline quantities. In our example, the item pipeline is 8.25; that consists of a depot segment of 6.75 and a base segment of 1.5. The closest approximation to this partitioning, a depot stock level of seven and a base stock level of one, is shown in Figure 2-8.

Expected Backorders = 1.86
7 Availability = 81.2%

1 0 0

Figure 2-8. Allocation By Pipelines

This distribution is better than either of the other two; however, it can be improved significantly. If one examines every possible allocation of the stock levels, the following optimal distribution emerges (see Figure 2-9).

Expected Backorders = 1.50
5 Availability = 84.6%

1 1 1

Figure 2-9. Optimal Allocation

Thus, it is possible, in this case, to gain another 3.4 percent availability (3.06 end items, on the average) without investing a single dollar in stock, simply by being smarter about distribution.

Lessons. Four fundamentally important conclusions can be drawn from this analysis, however simplistic the example. They are:

1. Spares optimization models provide a way to achieve specified levels of availability at substantially less cost than item-oriented policies; thus, they provide the policy maker with the opportunity to be conservative in spares investment while still providing effective weapon-system support.

2. Cost-effective stockage policies cannot be based on demand rates alone; all item characteristics must be considered.

3. The policy maker must view the depot and bases as an integrated system. One should not make policy for the "wholesale" level independent of the "retail" level.

4. Spares optimization models are more robust in the face of uncertainty than item-oriented policies.

LIFE CYCLE COST REVISITED

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ABSTRACT

In the early 1970s the Department of Defense (DoD) requested that the National Security Industrial Association (NSIA) review the status of Life Cycle Costing in the defense industry and make recommendations as to how DoD goals could be accomplished. NSIA formed an ad hoc committee to accomplish the study. That committee submitted its findings and recommendations in June of 1976. Thirty-eight recommendations were made in 7 major policy areas. (1) The DoD formed a special task force for their consideration and implementation. Recently the NSIA Life Cycle Cost ad hoc committee reconvened to reassess life cycle costing status and follow-up in its recommendations. This paper reports the results of that assessment.

INTRODUCTION

The Office of the Secretary of Defense (OSD) has long been concerned with the continuing growth of that portion of the total resources needed to operate and support new weapons and the decline in funds for new procurement. In the early 1970s OSD initiated several programs to achieve an overall reduction of each service's budget allocated to Operation and Support (O&S) cost in the out years by focusing on reducing O&S cost drivers during weapons system development. Central to this focus was methodology called "Life Cycle Costing."

Life Cycle Cost (LCC) is the total cost to the Government of acquisition and ownership of a system over its full life. It includes the cost of development, acquisition, operation, support, and where applicable, disposal. (2) Life Cycle Costing is the estimation and analysis of projected life cycle costs.

It was the OSD's desire to have life cycle costing applied in such a manner as to reduce O&S costs while simultaneously increasing readiness and insuring a sustained operational availability to meet mission requirements. This requires special understanding and continued attention and effort by the engineering and logistics communities during the Conceptual, Validation and Full Scale Development phases of the acquisition process. With this objective in mind, the Assistant Secretary of Defense for Installations and Logistics (I&L) requested that the Logistics Management Advisory Committee (LoMAC) of NSIA provide him with constructive comments and recommendations from a logistics view that could be applied to the DoD Life Cycle Cost program.

NSIA Task Force. The NSIA formed an ad hoc committee on Life Cycle Cost consisting of 50 members from 34 companies, chaired by the author of this paper. It was organized into five major subcommittees covering the Aircraft, Ship, Vehicle, Armament, and Electronic systems/equipment areas.

In its studies, the committee reviewed the development and status of life cycle costing and assessed its application to 48 different system developments and 34 different hardware item procurements. It specifically addressed 7 key areas:

- LCC Management
- Source Selection Considerations
- Logistics Alternatives Analysis
- Cost Driver Assessment
- Discounting and Escalation
- Data Base Development
- LCC Research

In each of these areas specific DoD objectives were formulated, their status assessed and recommendations made. These findings and recommendations were submitted in 1976 to the Assistant Secretary, who appointed a special task force for their consideration and implementation. In 1979 the NSIA reconvened the ad hoc committee to reassess Life Cycle Costing status and to follow-up on its recommendations. This paper presents the results of that reassessment.

LIFE CYCLE COST MANAGEMENT

DoD's objective was to have the Life Cycle Cost of a system managed throughout its development, production, and operational use. That type of management required that the cost controlling

characteristics of each system be specified, designed to, monitored, tested, and validated.

Findings. Initially, the ad hoc committee found that in the management of most acquisitions, funding was not routinely programmed for cost driver analysis and life cycle costing. Accordingly, these activities were not integral to overall development planning but were design/ logistic engineering fallouts, not controlled, managed, development characteristics.

Recommendations. The ad hoc committee recommended the following actions to institutionlize life cycle costing:

- LCC goals and requirements be specifically stated in requests for proposals and statements of work.
- Cost breakdown structures and hardware breakdown structures be correlated with contract work breakdown structures.
- Requirements for performance, reliability, maintainability, availability, and cost be correlated and compatible.
- LCC estimates be documented as part of program plans and require separate contract data items reporting.
- There be systematic updating of baseline LCC estimates.
- Life cycle costing, reliability analysis, maintainability analysis, and logistic support analysis be correlated to the line replacement unit of equipment.
- LCC estimate methodology be simplified and estimates tailored to required decisions.

Status. There have been significant gains in acceptance of life cycle costing by both Government and Industry. Initially life cycle costing was treated as a separate exercise, now it is accepted as part of "Phased Baseline Management." The new (draft) DoD Instruction 5000.2 formalizes phase baseline management as part of the DSARC (Defense System Acquisition Review Council) Milestone review process and the activities required for system acquisition funding approval. (3) The process delineated requires life cycle cost estimating and the establishment of LCC driver goals.

Phased baseline management integrates the control elements of technical performance measurement, risk control, configuration management, cost/schedule control, design-to-cost, integrated logistic support and life cycle cost into the system engineering process (see Figure 1). Three system baselines are defined: functional, allocated and product. Correlated to these baselines are system requirement and design reviews and related control element activities, including specific life cycle costing activities. (4)

Significant progress has been made in life cycle cost management, especially in the almost routine requirement for life cycle cost estimating. Life cycle cost estimates are being called for in almost all system level and in most equipment level RFPs. There is a formal LCC Contract Data Item (CDRL DI-F-30203) that is included in most Scopes of Work (SOW). That data item usually serves both for Design-to-Cost (DTC) and life cycle cost reporting.

Design-to-Cost is the Government's adaptation of the commercial concept of establishing rigorous cost goals during development and controlling these goals by practical tradeoffs between operational capability, performance, cost and schedule. (2) There have been trials at establishing a specific total life cycle cost as a design-to goal, but in general the trend has been to place design-to goals on system characteristics that drive those costs. However, there is still a lack of correlation of performance, reliability, maintainability, availability, logistic support requirements, and cost.

There is still a lack of coordination of life cycle cost, reliability, maintainability and logistic support analysis activities in Statements of Work and Development Planning and Programming. It is rare that the output of logistic support analyses can be directly input to life cycle cost analysis.

There is still a lack of coordination between Life Cycle Cost Breakdown Structures, Hardware Breakdown Structures, and Work Breakdown Structures.

SOURCE SELECTION CONSIDERATIONS

The DoD wanted the estimated life cycle cost and proposed plans for LCC minimization to be major considerations in source selection.

Findings. The committee found that estimated LCC was a consideration in source selection, however, its weight in the final decision was minimal. In most cases the proposed instant contract cost far overshadowed the estimated life cycle cost. In addition it determined that:

- Often LCC models specified in RFPs were incompatible with the program phase and tailoring of model for specific competitions was nonexistent or questionable.
- Frequently, operational profiles are not provided to competing contractors.
- Many times required data were not compatible with program phase design detail.
- Often the factors required from the Government such as military pay, training cost, etc. were not supplied to competing contractors.

PHASES	CONCEPTUAL/FORMULATION PHASE	DEFINITION/VALIDATION PHASE	FULL SCALE DEVELOPMENT PHASE	PRODUCTION/USER OPERATION PHASE
MAJOR ACTIVITIES	ESTAB. NEED OBJECTIVES REQUIREMENTS TECH. BASE ECONOMIC BASE PRELIM. PLANS SYSTEM CONCEPTS ALTERNATIVES IDENTIFY RISKS TECH. FEASIBILITY PRELIM. COST/ SCHED. ESTIMATES VALIDATE REQ'TS. PRELIM. SYSTEM SPEC., NECESSARY PLANS	SYSTEM/SUBSYSTEM ENG'RING. TRADE-OFF STUDIES CONTINUED TECH. & DESIGN ANALYSIS SPEC. UPDATING & EXPANSION RISK ASSESSMENT HARDWARE/SOFTWARE DEVELOPMENT/TESTING COST/PERFORM. ANALYSIS LOGISTICS SUPPORT ANALYSIS & PLANNING TEST & EVAL. PLANNING SCHED. & COST PLANNING DESIGN-TO-COST GOALS LIFE CYCLE COST MODEL CONFIG. CONTROL PROCEDURES SYSTEM SPEC. SUBSYST. PERFORM. SPEC., DETAILED PLANS	DETAILED DESIGN, FABRICATION, AND TESTING OF SYSTEM AND ALL SUPPORT ITEMS PRE-PRODUCTION HARDWARE/SOFTWARE (MAY INCLUDE SOME PRODUCTION HARDWARE) DEVELOPMENT TESTING & EVALUATION INITIAL OPERATIONAL TESTING & EVALUATION CONFIGURATION MANAGEMENT COST/SCHEDULE CONTROL TECHNICAL PERFORMANCE MEASUREMENT LOGISTICS SUPPORT DETAILED PLANNING HUMAN FACTORS & TRAINING PLANS TECH. DATA PACKAGE INCL. MF'G. DOCUMENTATION LONG LEAD ITEMS MF'G. FACILITIES PLANNING PRODUCTION ENGINEERING PRODUCT SPECS. TECH. DATA PK'GE.	INITIAL LOW RATE PRODUCTION FULL SCALE PRODUCTION FULL SCALE LOGISTICS SUPPORT IMPLEMENTED DEFICIENCIES & MODIFICATIONS CORRECTED & MADE OPERATIONAL TEST & EVAL. CONTINUED CONFIGURATION MANAGEMENT CHANGE CONTROL & IMPLEMENTATION DECISIONS RESULTING FROM OPERATIONAL USAGE
BASELINES	FUNCTIONAL	ALLOCATED	PRODUCT	
SYSTEM ENGINEERING PROCESS/ SYSTEM ENGINEERING MANAGEMENT	DEFINITION & REFINEMENT OF SYSTEM OBJECTIVES, OPERATING ENVIRONMENT, PERFORMANCE & DESIGN CONSTRAINTS, AND MEASURES SYSTEM EFFECTIVENESS	REQUIREMENTS ANALYSIS; FUNCTIONAL ANALYSIS, REQ'TS. ALLOCATION, TRADE STUDIES, DESIGN/EFFECTIVENESS ANALYSIS, SYNTHESIS, & ETC. GENERATION OF SPECIFICATIONS & WORK BREAKDOWN STRUCTURE	EXPANSION & VERIFICATION OF SPECIFICATIONS SYSTEM ENGINEERING MANAGEMENT ACTIVITIES PREP. OF SYSTEM ENGINEERING DOCUMENTATION TECHNICAL PROGRAM PLANNING & CONTROL ENGINEERING SPECIALTY INTEGRATION SYSTEM INTERFACES & DESIGN CHANGE IMPACT ASSESSMENT	SYSTEM ENGINEERING SUPPORT
	SYSTEM REQ'TS. REVIEW	SYSTEM DESIGN REVIEW	PRELIMINARY DESIGN REVIEW; CRITICAL DESIGN REVIEW	FUNCTIONAL CONFIGURATION AUDIT
TECHNICAL PERFORMANCE MEASUREMENT	PRELIM. MASTER PARAMETER LIST	MASTER PARAMETER LIST IDENT. OF CRITICAL PARAMETERS PREP. SUMMATION MODELS PARAMETER TREES INPUTS TO TEST PLANNING	IMPLEMENT TPM PLAN ASSESSMENT OF RESULTS OF ANALYSIS, TESTING, & SIMULATIONS IMPACT ANALYSIS, TECHNICAL TRADE-OFFS, & TECHNICAL CHANGES MEASUREMENT & DEMONSTRATION MILESTONES	EVALUATION OF OPERATIONAL TESTING & USER OPERATIONS
RISK	ASSESSMENT OF RISKS OF ACHIEVING SYSTEM REQUIREMENTS	ASSESSMENT OF RISK OF ACHIEVING DESIGN REQUIREMENTS. TRADE-OFF REQUIREMENTS RISK REDUCTION	CRITICAL ELEMENTS DEFINED. ACCEPT. SPREAD & THRESHOLD ANALYSIS AT TECHNICAL EVENT MILESTONES — TRADE STUDIES TO REDUCE RISK RISK REDUCTION AND/OR ELIMINATION. RISK MANAGEMENT.	ANALYSIS OF UNEXPECTED PROBLEMS & UNCERTAINTIES
CONFIGURATION MANAGEMENT	CONFIGURATION MANAGEMENT PLANNING	IMPLEMENT FORMAL CONFIGURATION MG'T. CONFIGURATION IDENTIFICATION CONTROL, AND STATUS ACCOUNTING UPDATE FUNCTIONAL BASELINE DEVELOP SPECIFICATION TREE	FULL & FORMAL CONFIGURATION MANAGEMENT SYSTEM SPECIFICATION UNDER CM CONTROL DEV. SPECS. UNDER CM CONTROL FOLLOWING DESIGN REVIEWS CDR FOR COMMITMENT TO PRODUCTION FCA VERIFIES COMPLIANCE WITH DEVELOPMENT SPECIFICATIONS	HIGH DISCIPLINED CONFIGURATION MANAGEMENT & CHANGE CONTROL. PCA IS FORMAL AUDIT OF "AS-BUILT" AGAINST TECHNICAL DOCUMENTATION USED TO ESTABLISH PRODUCT BASELINE
			PDR; CDR; FCA	PHYSICAL CONFIGURATION AUDIT
COST/SCHEDULE CONTROL	INITIAL PLANNING & COST ESTIMATING & COST/SCHEDULE CONTROL SYSTEM REQ'TS. ESTABLISHED	DEGREE OF IMPLEMENTATION TAILORED TO THE PROJECT PHASE. WORK PACKAGE PLANNING/CONTROL: BCWS, BCWP, ACWP, EAC INCLUDING VARIANCE ANALYSIS & MG'T. ACTION	FULL IMPLEMENTATION OF "EARNED VALUE" SYSTEM WITH DISCIPLINED PERFORMANCE MEASUREMENT OF SCHEDULE AND COST BY WORK PACKAGE BY PERFORMING ORGANIZATION	ESTABLISHED PRODUCTION PLANNING & CONTROL TECHNIQUES UTILIZED AS APPROPRIATE FOR TYPE OF PROJECT OR PRODUCT.
DESIGN-TO-COST	DEVELOP INITIAL STRATEGY ANALYSIS OF ALTERNATIVE DESIGN APPROACHES RE COST, PERFORMANCE AND EFFECTIVENESS	ESTABLISH DESIGN-TO-COST GOALS AND RATIONALE	FULL IMPLEMENTATION OF D-T-C PROGRAM D—T—C TRACKING PRODUCIBILITY ENGINEERING OF EVOLVING DESIGN	PRODUCTION ENGINEERING PRODUCTION UNIT COST ESTABLISHED INITIAL PRODUCTION RUN CHANGES
INTEGRATED LOGISTICS SUPPORT	LOGISTICS SUPPORT PLANNING LOGISTICS SUPPORT ANALYSIS ANTICIPATED SUPPORT ENVIRONMENT ALTERNATIVE SUPPORT CONCEPTS LIFE CYCLE SUPPORT GOALS	LOGISTICS SUPPORT PLAN UPDATE LOGISTICS SUPPORT ANALYSIS & PLANNING AS SYSTEM DEFINITION EVOLVES	SUPPORT EQUIPMENT, SUPPORT SERVICES, TRAINING, SPARES, AND DOCUMENTATION REQUIREMENTS ESTABLISHED ACTIVITIES INITIATED, AND PRODUCT/SERVICES MILESTONES ACHIEVED. EFFECTIVE INTERFACE WITH DESIGN/DEV. TASKS.	ILS PROVIDED. INITIAL PRODUCTION RESULTS/NEEDS OFTEN REQUIRE ILS CHANGES. RELIABILITY/MAINTAINABILITY VERIFIED
LIFE CYCLE COST	DEVELOP INITIAL STRATEGY ANALYSIS OF ALTERNATIVE DESIGN APPROACHES RE COST, PERFORMANCE AND EFFECTIVENESS	IDENTIFY CRITICAL FACTORS. DEVELOP LCC MODEL ESTIMATES FOR ACQUISITION AND SUPPORT HAVE BEEN VALIDATED	LCC MODEL UTILIZATION WITH INPUT DATA FROM DEVELOPMENT/DESIGN EVOLUTION, DTC TRACKING, INTEGRATED LOGISTICS SUPPORT, AND PRODUCTION PLANNING. UPDATING OF MODEL AS REQUIRED.	EVALUATION OF CHANGES

Figure 1. Phased Baseline Management (4)

Recommendations: The committee made the following recommendations:

- Provide competing contractors a standard LCC estimate accounting structure (model) tailored to the specific acquisition and type of hardware.
- Keep models and associated cost-estimating procedures as simple as possible yet consistent with required decision data.
- Explicitly define the known cost driver elements in the models provided.
- Provide "design-to" operational scenarios.
- Provide cost-estimating factors and methodology for those LCC elements common to all design concepts.

Status. Life cycle cost has become more important in the source selection considerations. Most of the time LCC breakdowns and "design-to" operational scenarios are being provided to competing contractors. More and more "standard" life cycle cost models are being developed and supplied by contracting agencies. Tailoring of models has improved, but too much time and effort are still being applied to cost elements that are not major factors. In many cases, Government provided Cost Estimating Relationships (CERs) and factors are still lacking.

LOGISTICS ALTERNATIVES ANALYSIS

It was the DoD's goal to use subsets of life cycle costing methodology as tools to integrate LCC considerations into hardware and logistic system design activities. Included in that methodology are:

- Logistic Support Cost Analysis
- Level of Repair Analysis
- Phased Logistic Support Analysis
- Reliability Improvement Warranty Analysis

Logistic Support Cost (LSC) analysis is an assessment of the expected cost of support related characteristics of a system or equipments design. It is used to compare and discriminate among design alternatives where relative support cost difference is the primary consideration. The significance of the results are, therefore, not based on the absolute value of support costs but on the magnitude of the cost differences between alternatives.

Level of Repair (LOR) analysis is an assessment of the most economical repair level and locations for a given system or equipment based on the cost of spares, repair parts, test equipment and maintenance manpower. It employs the use of cursory economic screening rules to identify those tasks in which the repair-level decision can be made without the requirement for a detailed, element-by-element analysis. It is also designed to provide guidance to designers on the advisability of design for discard at failure. The end product of LOR analysis is a maintenance scenario for each of the line replaceable units (LRUs) in a system. Like the LSC, it is not necessarily based on absolute values but upon the cost differences of alternatives.

Phased Logistic Support analysis is an assessment of the most economical time to "phase-in" the logistic support of a new system or equipment from the contractor to the Government. It is primarily an assessment of cost versus design stability. Its aim is to save on the cost of changes in the area of tools, test equipment, handling equipment, personnel training, manuals, and spares during the period of reliability immaturity.

Reliability Improvement Warranty analysis is an assessment of the cost of a long term warranty for the repair of equipment at a fixed price within a given turn-around time. The objective of the RIW concept is to provide an incentive to contractors to design and produce "low" failure rate equipment and to accelerate the reliability growth on "high" failure rate equipment.

Findings. The committee initially found that these analyses were being applied to some degree on several developments but not with any consistency or efficiency. Many times the specific analyses were not being tailored to the development under consideration. Sometimes logistic support cost analysis was used in lieu of total LCC analysis. Often, level of repair analysis was specified only to be cancelled due to funding shortages. Phased logistic support was frequently employed; however, it often was as a result of delayed support system development rather than for LCC minimization. Reliability Improvement Warranties were experiments, not yet debugged or accepted in general use.

Recommendations. The committee advised the following:

- Care be exercised not to replace LCC analysis with LSC analysis. That logistic support analysis be used primarily for support system design tradeoffs and that it be used to determine relative cost differences between alternatives.
- Application of logistic support cost analysis be tailored to the level of design definition being considered.
- Incorporate level of repair analyses into standard engineering activity for system design, but tailor them to design definition and operational and support constraints.
- Analyze all acquisitions for cost-effective phase-in of organic support.

- Make contractor support analyses the rule rather than the exception.

- Consider the integration of phased logistic support and reliability improvement warranties in analyses for life cycle cost minimization.

- Correlate the amount of planned reliability testing to the cost of reliability improvement warranties for life cycle cost minimization.

Status. Significant gains have been made in logistic alternatives analysis, especially from the top-down. The issuance of the new DoD Directive 5000.39 on the "Acquisition and Management of Integrated Logistic Support for System and Equipment" is a major step forward. (5) However from the bottom-up, the individual tools have been improved and are used with increasing frequency, but an integrated system engineering approach to their application is still lacking. The words are being said, but the actions lack coordination.

COST DRIVER ASSESSMENT

A key DoD objective for life cycle cost analysis was the identification of cost drivers early in the acquisition cycle. The major concerns were with cost drivers related to performance requirements, technology level, and standards and specifications. The DoD desired that cost driving performance requirements be challenged, technology be used to lower cost, and standards and specifications be applied rationally.

Findings. The committee found an increasing awareness of cost and cost drivers at most companies, but a reluctance to challenge requirements. It has become almost axiomatic to say that over two thirds of the life cycle cost of a typical system are operations and support cost and that these costs are determined by the end of the conceptual phase, but little is known about just how and what it is that fixes those costs. Furthermore, a frame of reference for the magnitudes of historical life cycle cost is lacking. After an estimate is made, it is difficult to judge the accomplishment from a life cycle cost standpoint.

Recommendations. The committee recommended the following actions:

- Establish LCC contributor baselines for each type of equipment.

- Correlate LCC model elements to identifiable cost drivers visible at each program phase.

- Correlate LCC drivers to cost management and control centers.

- Allocate "design-to" goals to known cost drivers.

Status. Earlier cost driver identification is happening. The new DoD Directive 5000.39 requires plans and resources to identify cost and readiness drivers on current systems by Milestone Zero. By Milestone I, these drivers are to be identified at a detailed level and targets established for the improvement of a new system. (6) The revision of DoDI 5000.2 contains suggested support-related goals based on historically recognized cost drivers -- Operational Availability, Sortie Rate, Manning, Maintenance related R&M, POL Consumption, and Spares.

Although life cycle cost drivers are receiving DoD attention at the top, LCC model elements have generally not been tailored for design level cost driver visibility. The following LCC models have seen widespread application in proposals and development programs:

- ADTC LCC Model

- AFLC LSC Model

- Army LCC Model

- Navy System Level LCC Model

- Navy Equipment Level LCC Model

- TRI-TAC LCC Model

- CAIG Operating and Support Cost Structures

In general they have propagated uniformity in life cycle cost estimating, but still require more specific tailoring for acquisition program phasing. Analysts are still spending too much time on less significant cost areas.

DISCOUNTING AND ESCALATION

It was the Government's objective that discounting and escalation be judiciously used in life cycle costing. Discounting was to be a consideration in cost benefit analysis, and escalation to be a consideration in affordability studies.

Findings. The committee found that the treatment of discounting and escalation varied from program to program and customer to customer, however, neither had a major impact on the contractor from a design standpoint.

Recommendations. The committee recommended the use of "now-year" dollars for contractor life cycle cost estimation for source selection competitions. When either discounting or escalation is to be included in LCC estimates, the factors used should be provided by the Government.

Status: Most RFPs and more recent contracts are requesting that contractors provide LCC estimates in both constant and current year dollars. In a few cases, escalated costs are being requested. Generally, a constant

escalation rate is assumed. Discounting rates are being provided for life cycle cost tradeoff studies. The following general life cycle cost analysis approach has evolved that includes the application of escalation and discounting: (7)

- Definition of the system in terms of cost characteristics.
- Definition of the system's life cycle and the activities that generate costs.
- Development of a Life Cycle Cost Breakdown (LCCBS) that structures those activities to specific categories of accountability.
- Development of Cost Estimating Relationships (CERs) for each element of the LCCBS.
- Structuring of the CERs into an LCC estimating model.
- Development of CER inputs and estimation of LCC in constant current year dollars.
- Development cost profiles in current year dollars.
- Development of LCC estimates and cost profiles in constantly escalated out year dollars.
- Identification of cost drivers and sensitivities.
- Determination of cause and effect relationships.

Usually, the LCCBS is provided by the Government.

DATA BASE DEVELOPMENT

It was DoD's objective that data bases be developed by both the services and industry to permit life cycle cost to become a "design-to" system characteristic.

Findings. The committee found that both contractors and contracting agencies were lacking accountable historical life cycle cost data. This was true of both cost data itself and the data from which cost can be calculated, e.g., reliability, maintainability, logistic turn-around times, etc.. Although much data exists, it had not been collected, analyzed, or catalogued for LCC analysis application.

Recommendations. The committee recommended that:

- Industry be encouraged to develop cost data banks and cost estimating relationships capable of supporting LCC studies for each phase of development, and be able to recover those costs in a manner that encourages such investments.
- DoD establish a LCC information system centered around individual data banks located at procuring agencies. Those data banks should include not only cost, but also reliability, maintainability, logistic data and budgetary planning factors.

Status. Most contractors have established some level of internal LCC data bank. Most of these banks are informal developments but a few have been accomplished as formal IDP activities. Although the situation is improving, data bases for design-to life cycle cost are still lacking. A major gap exists in the development cost data area as well as O&S cost.

The DoD has increased its internal data base developments to help correct the lack of weapon system Operation and Support (O&S) cost data; the CAIG (Cost Analysis Improvement Group) has established structures for O&S cost estimates to be presented to the DSARC (Defense System Acquisition Review Council); and the OSD (Office of Secretary of Defense) established the VAMOS (Visibility and Management of Support Cost) study for the development of a data bank for weapon system operating and support cost. The CAIG also established the DoD Cost Analysis Data Bank of historical procurement costs.

Each of the services is maintaining cost factor manuals or handbooks. Many of the contracting agencies are in the process of building data banks.

LIFE CYCLE COST RESEARCH

The DoD's goal was to use new technology for the reduction of LCC, including if necessary, changes in support, manning, training, and organizational concepts. It was DoD's goal to design systems and equipments in consideration of a broader look at life cycle costs. While there had been efforts to develop methods to cover first order LCC drivers such as reliability and maintainability, insufficient thought, reasoning, and control had been applied to those system characteristics considered extrinsic to the weapon system.

Findings. The committee found little coordinated LCC research currently underway in industry. There were some isolated activities generally appended to on-going development, on the development of cost estimating relationships, LCC modeling, reliability growth, training technology, reduced maintenance design. There were very little recognizable applications of new technology for the specific purpose of life cycle cost reduction. There was little real conceptual activity within industry related to challenging existing military systems of operation or support.

Recommendations. The committee recommended that DoD:

- Research application technology specifically for the reduction of total life cycle cost. Direct that research at modifying or changing drivers in each weapon systems area.

- Research increased standardization. Emphasize equipment level form and fit. Strive to raise standardization levels higher and higher. Correlate with factory repair, if necessary.

- Look into the "real" impact of acquisition schedules on life cycle cost. Correlate this effort with phased logistic support, reliability growth, and design stability.

- Expand manpower reduction research beyond the direct operations and support personnel into the indirect personnel. Place more emphasis on designing men out of the total system.

- Provide more research into the man/machine interface. Look for means to revise and integrate information transfer concepts with support concepts to optimize manpower life cycle costs.

- Research transportation systems measured against flexible support concepts (e.g., Depot at Operating Base vs. Transportation Net).

- Research consolidations of facilities, support equipment, and test equipment to reduce logistic support costs.

- Research methods for design interface/impact. "First, design for support; then, support the design."

Status. There has been increased recognition of the need for LCC research. The NSIA has devoted several "mini" seminars to the subject. Most of the activity to date has been in the areas of Contractor Support, and Warranties and Guarantees. There has been some activities in standardization but generally these were not planned as LCC research. There is still the need for a coordinated LCC research activity in which industry is incentivized to complete and participate.

SUMMARY

The NSIA ad hoc committee was encouraged by the progress made in life cycle costing. Many of its recommendations had been implemented. There seems to be a general acceptance of the methodology throughout the Department of Defense and Industry. Although there is still a lack of data and totally integrated programs, life cycle costing methodology is improving, life cycle cost consciousness is growing, and life cycle cost control and minimization is starting to happen.

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FEDERAL BUYING AND ORGANIZATIONAL BUYING

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LESSONS TO BE LEARNED BY DOD ACQUISITION MANAGERS
FROM THE COMMERCIAL PROCUREMENT WORLD

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ABSTRACT

For many years America's industrial firms have been developing and refining the optimum procurement process for the conduct of commercial buying. These techniques have withstood the test of time and have proven their value in one of the world's most demanding environments, the commercial marketplace. This is a forum where only the best concepts survive and where a longstanding fundamental percept must, by definition, have intrinsic merit or it will soon disappear.

Recognizing that when the federal government enters this procurement arena there are basic differences from the normal commercial buying situation, still, there are enough similarities to make a study of some of the commercial processes valuable. Congress, the President, DOD and certain other federal agencies have all placed legitimate constraints on DOD acquisition managers. Yet in the end, the task of the DOD acquisition manager is essentially the same as that of his counterpart in the commercial world, getting the best deal for the organization he serves when he sets out on the acquisition trail.

In this paper I shall discuss some of the observations and conclusions that have become apparent to me over the twenty-five years that I have been involved with both the commercial and government acquisition process. These points are fundamentals of the commercial procurement world, but are given little if any emphasis in the DOD acquisition system, much to the detriment of DOD in my view. Thus, as I see it, these are lessons to be learned by DOD acquisition managers from the commercial procurement world.

STICK WITH A WINNER

This is perhaps the most basic rule of procurement in the commercial arena. Find a good supplier. Put pressure on him to give the best possible price. Demand schedule and quality results. But if he comes through for you, love him, nuture him and reward him with more business. If he is a "good" supplier, he will perform for you over and over again.

I am fully aware that in the DOD acquisition cycle, Congress, public law and many DOD top managers exert heavy pressure on the buying process in favor of competition. And let me emphasize that the author is not advocating a world exclusively made up of sole source buys. Absolutely not! But over and over again I see instances where a government agency with an excellent supplier recompetes a follow-on buy and awards it to a marginal contractor. This second contractor then fails to perform, causing shortages in the field, and weakening our country's already less-than-full-strength defense capability. And why was this done? The answer is usually "to save a few dollars." I ask you, in these cases, where is the savings? You and I both know the decision was stupid. So why do we allow these things to happen. DOD acquisition managers must stand up and defend a non-competitive action when competition is clearly inappropriate.

I was cheered this past year when one of the military services awarded my company a sole-source follow-on when it could be demonstrated that savings in excess of ten million dollars would accrue and a break in production would be averted, even though originally a directive had been issued to the buying agency to compete the follow-on buy. Unfortunately, most of the justification and convincing had to be done by the company's marketing department. It was only after a protracted sales effort at the so-called "working" level had finally convinced the contracting officer, that he then took the matter forward to his superiors in the field, and finally to Washington for top management concurrence, that the sole-source award finally happened. And all this effort took more than a year. However, I think the best result for the government finally prevailed.

Contrast this case with another experience of my company near the end of the war in Vietnam. We had been the only supplier of an item for a five year period and had made 1,000 of them, all with good quality, and all in accordance with contract schedules. Now the government needed what everyone knew would be a "final" buy of two hundred more. A competition was held. On a five million dollar order we were underbid by fifty thousand dollars. A small business in serious financial difficulty got the order. Halfway through the job the company ran out of money. The government had to invest several million more or lose its hardware. Since the company lacked engineering capability, it was unable to make the equipment work without a large infusion of technical assistance from government engineers. Quality never

was up to contract specifications, so requirements were relaxed. Worst of all, the war was over before any equipment could be delivered. Does this story have a familiar ring? It should. It happens every day at some DOD acquisition site. All in the name of "following the regulations."

Could the above story be averted. We all know the answer is "yes" if we really wanted to make it come out right. In my company's case, the contracting officer and several of his supervisors told us before they awarded the problem contract that they knew it was the wrong thing to do. But nobody stood up to be counted.

Compare this case with my company's experience with a major retailer, a company known for its quality products at competitive prices. For more than twenty years we have been its sole-source supplier of a major segment of its hardware business. This retailer is no "babe-in-the-wood." It annually purchases billions of dollars of manufactured goods. Yet year after year it sticks with the same vendor. Why? Because it is in the buyer's best interest.

HELP TO INSURE YOUR SUPPLIER GETS RICH

This is another fundamental. The best contractors are those which are making a satisfactory profit since they are not forced to take shortcuts in order to come out whole on a program. The normal government procurement action is diametrically in opposition to this principle. DOD acquisition is "cost based." Cost, plus a small going-in profit, normally equals price. How different from the commercial world where price is a derivative of the market place and cost versus price may or may not yield a profit.

The DOD acquisition situation is different argue the sceptics. There is no real competitive market-place. I grant you this is sometimes true. However, although all fighter aircraft are different they are not that different. Moreover, most government buys are relatively prosaic and not for glamorous expensive fighter planes. But regardless of what he is buying, the DOD acquisition manager normally follows the same rule. He tries to drive down the price of his supplier.

Think of things differently. If the DOD manager had followed a technique more akin to the "should cost" approach, and had come to the conclusion his contractor was giving him a good price, regardless of the contractor's cost, and if the contractor felt he had a "comfortable" profit, would not that contractor be more apt to fully meet all contract requirements? We all know the answer is a resounding "yes."

The author is not arguing for any government give away schemes. Contractors must have competitive prices to win a government order. A smart commercial buyer wants his supplier to make money on his contract, the smart government buyer will feel likewise.

GIVE YOUR CONTRACTOR A FREE HAND
TO MANAGE HIS PROJECT

Who was the best boss you ever had? Wasn't he someone who told you what he wanted, and when he wanted it, and then pretty much left you alone? Occasionally he checked to see how things were progressing, and if you were having problems he offered assistance; but if you were progressing well he left you alone to proceed towards your goal.

The same situation exists in the world of acquisition. Good contractors need the contract terms clearly laid out for them. Occasionally they may need help, and certainly a buyer has a right to make periodic checks to monitor his contractor's progress. But that's it. If progress is good the buyer should back off and not suffocate his contractor. All too often, this is not the way it works with the DOD acquisition process.

Consider "operational audits" by DCAA, or DCAS procurement audits, or compensation surveys, or estimating system surveys or quality control audits. All of these are well-intended programs that have worthy objectives. However, they all fall into the "suffocation" category.

Commercial contractors for the most part do not fall into the suffocation trap. Buyers select suppliers in whom they have confidence. Then they monitor supplier progress in a relatively arm's length fashion. If the supplier is having problems the commercial buyer takes appropriate corrective action. If supplier progress is satisfactory, the loose control approach continues. This is the way we contract to have houses built. This is how highways are constructed and commercial airplanes, and cars, and trucks, and blankets, and clothing and, in fact, just about everything in the commercial world.

Contrast this commercial approach with resident DCAA auditors, resident DCAS inspectors, resident DCAS production specialists, AFPRO and NAVPRO offices at contractor facilities, plus the mind-boggling number of surveys to which the typical contractor is subjected by DOD. These include those mentioned above plus insurance surveys, security surveys, and accounting system surveys. The list is almost endless.

Instead of the traditional DOD approach, why is not more emphasis placed on ideas like the CWAS (Contractor's Average Share in Cost Risk) concept? This technique recognizes that contractors who have a high percentage of competitive fixed price business have ample motivation to run their businesses in the most efficient manner and therefore do not have to be watched as carefully by the government. In the 1960's this concept took root within DOD and began to grow in scope. Somehow, however, the DOD top brass grew nervous. Congress was watching. So were the professional critics. So CWAS began to atrophy. By the late 1970's there no longer was a CWAS committee at

the DOD Headquarters level. DCAA top management was stating it could see no advantages in a contractor being "CWAS qualified." CWAS, if not dead, was surely dying.

But why? In the commercial world this is the normal approach. If it works in this largest of all market places, why can't it work in the DOD acquisition world?

DCAS has a similar pilot program in the quality area, CAP (Contractor Assistance Program). Under this system a contractor's quality system is surveyed. If it is adequate then the government does not inspect contractor hardware. Rather, by auditing the system and then standing back and letting the contractor inspect the hardware the government goes ahead with the acquisition process. Is the government getting acceptable hardware under this approach? So far, all evidence says "yes." The bad news, however, is that this system has been in existence for several years and there are only six contractors presently participating in a pilot project. There should be six hundred, or six thousand.

GIVE THE CONTRACTOR A GENERAL REQUIREMENT AND ALLOW HIM TO WORK UP DETAILED SPECIFICATIONS

In the commercial world if you want a house built you go to a builder. Typically, you tell the builder what you have in mind and then ask him for suggestions. He is the expert who can give you valuable cost reduction tips, ideas for improved quality and a wide variety of design improvement approaches. If you are unhappy with one builder's proposals, you then try a second. Only in the rarest of cases would you lay out all the specifications and expect the contractor to rigidly adhere to them without any two way dialogue.

Contrast this approach with the average DOD procurement: In this latter case myriad specification requirements are the norm, not the exception. The contractor is normally not allowed or expected to make inputs. Again it can be argued that government procurement is different, and in some ways it is, but all too often this is an excuse for taking the easy way out. If you make everybody bid on exactly the same specification, then no one has to make the hard choices between different concepts at different prices. But you also fail to take advantage of the money saving ideas of the experts you choose to have bid on your project.

Would you ask your homebuilder to place studs on fifteen inch centers when everyone else in the business was building on sixteen inch centers, with paneling being precut to fit the sixteen inch standard? Or would you direct a builder to use an obscure roofing material, or an off-brand, hard to get type of window, or an unusually elaborate type of brick? You would only do this if you were prepared to pay "top dollar" for what might be less than top dollar quality or schedule. But this is what goes on in DOD acquisition all the time.

A-109 is a big step forward. The author strongly supports this important relatively new groundrule. Unfortunately, it is only applicable to a limited number of the largest defense acquisition projects. Much more needs to be done to spread A-109 type thinking throughout the entire DOD acquisition arena.

CONCENTRATE ON COST REDUCTIONS NOT PROFIT RATES

The ultimate objective in all procurement actions, government or commercial, is getting what you want, when you want it, at the lowest overall acquisition cost. The key element is cost to the buyer. Profit, or lack thereof, to the seller should be of relatively little interest. (Except for the author's earlier admonishment that you want your supplier to get rich).

Most DOD acquisition studies that are concerned with the dollar and cents aspects of procurement, however, focus on profit not costs. The Weighted Guidelines concept is a classic example. Essentially, weighted guidelines deal with the roughly ten percent of a contract that is the profit portion, not the ninety percent that is the cost portion. In the decade of the seventies various studies were sponsored by DOD to improve the weighted guidelines concept by attempting to better motivate contractors to accept fixed price contracts or invest in capital facilities. However, no matter how much emphasis was given to making this section better, it only dealt with the ten percent chunk, not the ninety percent portion. Thus, in the author's view, DOD has been concentrating on the wrong target if the objective is lowering acquisition costs.

Weighted guidelines are also addressed solely to "going-in" profit, not "final" profits. No matter how attractive going-in profits may be as a motivator to a contractor, it is what the contractor is able to keep when the job is over and all books are closed that is his real concern. Contract unknowns, risks and hidden problems all eat away at his profits. So do defective pricing audits, GAO audits, the Vinson-Trammell Act and many other contingencies that only arise after the contract performance period is over.

Far more important than profit considerations are the cost reduction aspects of DOD acquisition. These may include effective negotiations, substituting materials, allowing adequate lead times, multiyear procurements, simplified designs, contractor input to design requirements and disengagement techniques to name a few ideas. These are the areas where the big dollar savings can be made.

ABANDON THE IFB SYNDROME

The whole DAR, ASPR approach to procurement has always been IFB based. All procurements are to

be conducted on this basis unless certain exceptions apply. The problem is, for most of the money spent by DOD, an exception applies. This is a topsy-turvey world of Alice-in-Wonderland.

The author believes in competition. He thinks there is an important place for IFB's. But why not rewrite the acquisition rules to say that one must use the appropriate contract vehicle for the circumstances? This will eliminate the present absurdity that forces buyers to document files and spend their efforts proving the obvious instead of proceeding with the job of buying.

The present system frequently results in buyers using IFB's in cases where specifications are not fully developed and where the IFB approach almost guarantees later claims from the contractor. So where was the saving, or what was the benefit of the IFB?

STOP WORRYING SO MUCH ABOUT THE CONTROL OF IR&D AND B&P

In any business situation except government procurement, buyers expect to pay something, as a portion of the cost of an item, for the development and marketing expenses involved in bringing the product to the marketplace. If the seller tries to load too much of this cost on the product, buyers do not buy. Or if a potential seller spends IR&D or B&P monies on products that will not sell, the seller suffers. The marketplace determines whether or not the seller's decisions were good ones.

Somehow, the government acquisition world has terribly distorted the subject of IR&D and B&P. These items are considered in at least some DOD acquisition circles as if they were products a contractor was trying to sell. Our larger contractors must make advance agreements to be sure the government adequately controls these expenditures. Smaller contractors have to satisfy government authorities as to the reasonableness of these expenditures. The real facts are that these are simply costs of being in business and staying in business.

Somewhere along the line we have missed the point. The key is getting the best price out of your contractor, not how he spends his money. If a contractor wants to drop all IR&D expenditures so that he has the lowest price, let him do it. On the other hand, if he wants to spend unusually large amounts on IR&D, but yet he offers the lowest price to the government, this should be acceptable also. This is just one more area where a mystique has grown up that government acquisition means different acquisition, which means heavy controls are necessary. The facts are, this is not necessarily the best way of doing business.

ELIMINATE OR REDUCE THE USAGE OF THE TERMINATION FOR CONVENIENCE CLAUSE

One of the most expensive elements in the DOD acquisition process is the termination for convenience clause. This clause, more than any other, makes contractors unwilling to undertake the long-term facility investments DOD is so agressively encouraging. And this helps keep DOD acquisition costs high. Moreover, because of the fear of convenience terminations, contractors must price all contracts a little higher to cover added risk possibilities.

The argument in favor of the clause is always that when wars end the country must be able to turn off the war production lines. Fortunately, we generally are not in war periods. At best the clause should only come in existence when the President declares a state of emergency. Somehow the concept has arisen that without such a clause, the government would not be able to stop a job in progress if it decided such a step were in order. However, the commercial world has such a procedure which could readily be adapted to government use.

The other argument used in favor of the clause is that without it costs might go up. But if such a change were made, perhaps overall acquisition costs might go down. This could well occur because government buyers might be more careful in placing orders if they knew that terminations were going to be more expensive. In the author's experience, all too many procurement actions are entered into by government buyers on the theory that if things do not work out the contract can always be terminated. This is a very bad practice. Additionally, if the clause were eliminated costs associated with the potential risk of convenience terminations could be avoided.

On top of this, it is the author's contention that, on the average, the government always pays one hundred percent of the contract price in the termination for convenience situation. Thus the government is paying extra for the privilege of using a termination clause that does not buy it a thing, and while doing so, it is deluding itself into thinking it is getting a bargain. In fact, the government is getting a bad deal because of lack of cost savings and a failure to motivate contractor investment.

Consider the following particulars. On the average all terminations are made at the halfway point in a contract. Some terminations come sooner, some come later, but this is the average. So on the average, the government always pays half of the cost of an item it terminates.

Then there is settlement expense. Typically this runs in the range of ten percent. Likewise, there is usually an equitable adjustment for unused facilities, buildings or other items. Again this can average ten percent. Next we must consider the cost of maintaining government termination specialists as well as contractors keeping and training their own termination experts. If these two each add ten percent to the cost of the average termination, we now are at the ninety percent level. Add in the extra termination costs from sloppy contracting and a cost factor for the higher risk factors contractors must build into

contract costs to cover the risk of termination and you easily reach one hundred percent of costs for your average item terminated at the halfway point.

The sceptic says, it cannot be true. The author is playing a numbers game. But in the author's own experience it has happened at least twice. Both cases involved terminations amounting to several hundred thousand dollars. In one case, the government paid more than one hundred percent of the contract price in a termination for convenience. In the other, it paid one hundred percent of contract value for five contract items, two of which were terminated at a partial completion stage. In each instance the contracting officer was told in advance what would happen, and in each case he elected, with full knowledge, to go forward.

The termination for convenience clause can only be deemed an expensive luxury.

USE MORE INNOVATIVE PROCUREMENT TECHNIQUES SUCH AS PREDETERMINED OVERHEAD RATES

Some ten years ago a DOD study group originated the idea of getting contractors to accept predetermined overhead rates as a way of motivating them to good cost performance. The author's company agreed to be one of several contractors that would participate in a pilot project. Before it could get started, however, other elements in DOD decided to cancel the project because of fears that things might not work out satisfactorily and, therefore, DOD management might be open to criticism for wasting taxpayers dollars.

From the author's viewpoint this was a big mistake. As has been stressed repeatedly in this paper, motivation of the contractor and a free hand to perform are the keys to improved performance and lower costs. Here was a golden opportunity to demonstrate this approach and DOD did not follow through.

Perhaps this idea should be brushed off and updated. If not this concept, some others should be tried. In any event, we should not be afraid to experiment with new concepts if they have the potential for improving the DOD acquisition process.

GIVE CONTRACTORS GREATER OWNERSHIP INTERESTS IN TECHNICAL DEVELOPMENTS ARISING UNDER A CONTRACT

The two usual government rules concerning ownership of inventions under a contract are that they belong to the government and the developing contractor obtains a license, or the developing contractor owns the invention with the government having a license. In recent years most of the pressure has been towards greater government ownership or control. Somehow the idea has arisen that this is "fairest" to all the citizens and this will maximize the possibilities of the invention being turned into useful commercial products.

Unfortunately, in most cases, things work in just the reverse manner. If a company has exclusive ownership of an idea it is much more willing to invest its own funds in growing the idea into useful commercial applications. If ownership must be shared, motivation decreases.

If the government really wants to motivate contractors, it will develop a system of ownership of patents and technical data that maximizes benefits to the developing contractor, while reserving to DOD only those rights necessary to meet the DOD mission.

ELIMINATE "BEST AND FINAL" OFFERS

Only in the world of government procurement do we find such frequent usage of "best and finals." DOD acquisition managers seem to feel there is something special in the systems they procure that frequently require them to use this technique. While this may be true, as an experienced "outsider" looking in at the DOD acquisition process, this author has never been able to understand the rationale.

The commercial marketplace, although much larger and much more complex, does not need best and finals. Buying satellite communications, elaborate data processing systems, or commercial jet aircraft are comparable activities to DOD acquisition. If best and finals were "magic" they would be used here also.

In the author's view, DOD continues to use this approach for historical reasons, as a "taking the easy way out" approach, or to gain the advantage of technical leveling. None of these reasons stand up to scrutiny and in the author's view the concept should be rejected. Rejecting best and finals will shorten procurement cycles and consequently lower costs.

REDUCE THE USAGE OF MULTIPLE INCENTIVE CONTRACTS

Multiple incentive contracts are wonderful, the perfect answer, on the day they are signed. Thereafter, things almost always go downhill.

In the middle of a program conditions usually have changed. The customer wants more weight taken out of the vehicle, but the contractor realizes he will get more money for accelerating schedule, so weight be damned. Over and over this happens.

Far better is an incentive contract with only a cost incentive, or perhaps just one "extra" incentive. Even better in many cases is the simple firm fixed price contract. More and fancier is not necessarily better; all too often, it is worse.

SUMMARY

There are many ways the DOD acquisition process can be made better. One of the areas that can be profitably studied for ideas on improving DOD

acquisition is the commercial procurement world. In this paper the author has attempted to highlight a few commercial concepts that have ready application to DOD. These concepts, if accepted, then can be lessons learned by the DOD acquisition manager from the commercial procurement world.

RAISING GOVERNMENT PURCHASING EFFICIENCY THROUGH INDUSTRIAL PURCHASING TECHNIQUES

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ABSTRACT

Government purchasing suffers a number of inefficiencies compared to its counterpart in the private sector and these are not necessarily endemic to the public sector. The differences between defense and industrial procurement which account for the most obvious inefficiencies are in matters of budgeting, life cycle costing, price security, source selection, supplier leverage, lead time control, and organization. Government purchasing offices often are unable to take advantage of exceptionally attractive, one-time buying opportunities because of inflexible budgets. They must reveal pricing information, which often results in government being forced to patronize marginal suppliers. These and the other named deficiencies indicate that the efficiency level of government procurement can be substantially improved through the application of techniques and procedures developed and demonstrated in the industrial sector.

INTRODUCTION

The argument of this paper is that government purchasing suffers a number of inefficiencies compared to its counterpart in the private sector and these are not necessarily endemic to the public sector. Consequently, there is reason to believe that techniques and approaches which have been successfully applied in the private sector to achieve efficiencies can be adapted to the circumstances of public sector procurement. This will require substantial change in the way public sector purchasing is currently conducted, but the obstacles to these changes do not appear insurmountable.

While public sector purchasing is conducted at local, state, and federal levels, the focus of this paper is defense procurement at the federal level. The dollar value of defense procurement not only dwarfs that of all other public sectors, including federal non-defense procurement, but is the most sophisticated in that it involves highly technical items incorporating extensive research and development. By the same token, private sector procurement embraces a bewildering array of businesses of all sizes and types including a host of private institutions. For this reason, only procurement techniques and methodologies employed by large industrial firms, including utilities as well as manufacturers, are compared with those associated with federal defense procurement.

It is reasonable to compare defense procurement with procurement by large industrial firms because both are conducted with much the same ends in view. Both seek to support operations efficiently, buy competitively products which meet desired specifications and are supported by adequate services, keep inventories balanced, maintain reliable sources, and develop competent personnel. It is recognized that defense procurement and industrial procurement operate in different environments, i.e., under a different set of constraints. However, this paper attempts to show that these differences are more matters of degree than of kind, more trapping than substance.

FLEXIBLE BUDGETING

Government buying offices have much less budgeting freedom than do industry purchasing departments and could substantially enhance their effectiveness if greater flexibility could be introduced into the budgeting system. The widespread practice of flexible budgeting enables industrial purchasing departments to take advantage of buying opportunities, as when large quantities of materials are unexpectedly offered at substantially reduced prices. Corporate buyers would typically have little difficulty obtaining funds to make such purchases, not because they are exempt from budget constraints but because corporate financial management recognizes the need for reasonable flexibility in applying these constraints.

Since purchasing budgets are based on estimates of requirements, a considerable margin of error is likely to exist. Material requirements can be influenced by a number of conditions beyond the control of the purchasing manager or his company. Changes in design, altered production schedules, new technological developments, and escalating costs are some of the more obvious circumstances which can substantially alter the quantity and character of a firm's projected requirements for materials and with it the funds required by purchasing. Only flexible budgeting enables a corporation to cope with deviations

from estimated requirements without suffering serious disruptions to its operations.

The merit of a flexible budget is that it can be adapted to actual experience. For example, if output of 100,000 units is planned but only 80,000 are produced, the total cost of production and distribution would not decline by 20 percent because of overhead costs. Flexible budgets are prepared so as to permit the revision of cost and purchase estimates with changes in production volume as well as to allow for changes in purchasing expenditures which can be justified on a total cost versus total savings comparison.

A fairly typical flexible budget procedure begins with the preparation of a series of estimates of balance sheet and income statement items based on operating results of a normal year and is increased in steps of 5 percent to a maximum of 25 to 30 percent of the normal year value. These estimates also would be decreased in steps of 10 percent down to the breakeven point, i.e., that percentage of production capacity below which operations would incur a loss.

Another procedure which accomplishes the same result is to determine the amount by which balance sheet and income statement items vary with variations in output from a normal level. This results in rates of variability for each balance sheet and income statement item corresponding to a given variation in production volume from its normal level. For example, a 1 percent increase in manufacturing output might result in an increase in the maintenance budget of 0.85 percent. A 1 percent decrease in manufacturing output might result in a reduction of the maintenance budget of 0.15 percent.

This brief commentary on flexible budgets is not intended to suggest that government purchasing officers have the prerogative of requesting a change in established governmental budgeting procedure. It is intended to suggest that a study of flexible budgeting procedures might suggest ways to accomplish the same results within the present federal budgeting system.

Some state purchasing departments, Michigan being one, have achieved a significant measure of flexibility by means of a revolving fund. While the purchasing department must account for this fund in the form of cash, unissued stores, or debits against other departments, the director of purchasing can authorize its use to maintain a central store of standard items used by several departments, increase quantities purchased to achieve more favorable price and discount terms, as well as make acquisition of scarce materials on favorable terms when the opportunity to do so might be lost by delaying action until the routine of approval and special appropriation can be completed.

There are numerous examples of the need for some semblance of flexibility in budgeting government procurement. One that comes to mind is the case of the Xerox computers at the Nellis Air Force Base test center in Nevada. These machines are at least fifteen years old. When Xerox abandoned the computer business, the company offered to sell the Air Force any quantity of spare parts so it could keep the computers operating. But procurement could not get the authorization from the various Air Force commands for sufficient funds to make such a bulk spare parts purchase. As a result, the entire Xerox spare parts inventory was purchased by Honeywell and placed in the firm's Boston depot. While these parts can be purchased by defense procurement from Honeywell, buying them piecemeal from the Boston depot is not only time consuming but incurs shipping costs. Moreover, it has been reported that computer operations at Nellis have been interrupted for substantial periods of time awaiting the shipment of parts across the country. (1) This would appear to be a high price to pay for whatever merits an inflexible budgeting system are supposed to offer.

LIFE CYCLE COSTING

The term "advertised bidding" has special meaning to government procurement officers. The culmination of the advertised bidding procedure (i.e. preparation of the IFB; its distribution; the public opening, reading, and recording of the bids; their evaluation; and award) is the award of a contract to that responsible bidder whose price is lowest. This procedure makes no allowance for product reliability and the cost of maintaining the product over the course of its useful life, including the cost of spare parts as well as the cost of maintaining an adequate inventory of them. It ignores basic effective purchasing, the kind industry uses routinely.

One of the most useful concepts developed in the industrial sector is that of Life Cycle Costing (LCC). This concept has applicability to government procurement as a GAO report (B-179214) to the Congress concerning it revealed as early as 1972. However, evidence suggests that the concept has had limited acceptance in government procurement. A recent purchase of steel-tipped cutting tools using a federal specification and awarded to the low bidder is cited by Lee and Dobler (2) as a fairly typical example of government procurement. While steel-tipped cutting tools are lower priced than carbide-tipped tools, industry has long since changed to the higher priced carbide-tipped tools. Their longer life and lower down-time for setups make their total cost substantially less than that for the lower priced steel-tipped tools. One can also cite examples in which giving a vendor lattitude in bidding can save the buyer money.

These comments are not intended to imply that there are but few instances when price should be the controlling factor in a purchase. Rather, the intent is to observe that procurement, probably at all levels of government, is frequently

and unnecessarily hampered by restrictions on procedures for competitive bidding. While such restrictions simplify procedures and enable buyers with less training and experience to implement them, they frequently are responsible for higher materials costs.

PRICE SECURITY

Price security is a practice long adhered to by industrial purchasing managers, because revealing price information can seldom help buyers and it may severely jeopardize their efficiency. A vendor might be willing to temporarily price materials "below the market" for a number of reasons. However, such a vendor would not want either his other customers or his competitors to know this fact. The former might well demand similar prices and the latter might take advantage of him by publicizing the prices and alleging that the commodities were of inferior quality or accuse the firm of discriminatory pricing. Consequently, the federal requirement that unclassified negotiated awards over $25,000 be publicized can substantially reduce the effectiveness of government buyers.

Knowing that the government reveals prices would lead a vendor having a choice to prefer doing business with an industrial rather than a governmental agency. The vendor who does bid on a government competitive negotiated contract would probably bid at a higher price than would be true if there were no fear of price disclosure. The inevitable result of this situation would seem to be that government buyers often are forced to deal with marginal suppliers, those who have little patronage from the private sector, or pay high prices than their private sector counterparts for comparable goods.

FREEDOM IN SOURCE SELECTION

The typical industrial buyer is free to select suppliers on the basis of total value offered, i.e. after comparing the cardinal attributes of quality, service, and price, as well as responsiveness, capability, maintenance costs, attitude toward customers, and reciprocity. Contrast this with source selection by a government buyer, which is largely automatic under formal advertising and indirectly restricted under negotiated procurement.

Moreover, most purchases exceeding $10,000 must be given advance publicity in the Commerce Business Daily and publicity of lesser amounts is strongly encouraged. Small vendors also are encouraged to bid on government contracts through Small Business Seminars. The result of this combination of publicity and encouragement of small vendors is to load bidders' lists with suppliers of questionable capability and reliability. While it is unlikely that such vendors would be awarded contracts, increasing the size of bidders' lists adds to the cost of procurement with few offsetting benefits and tends to create an "unreliable bidders" problem.

EXERTING LEVERAGE ON SUPPLIERS

Suppliers who do not live up to their capabilities or who do not interpret design specifications favorably for the buyer are not exceptional either in the private or the public sector. However, buyers in the private sector have a very effective defense against this tactic - the threat of withholding future business. Due to the difficulty of writing specifications that recognize every contingency, suppliers often have considerable discretion in interpreting government specifications. Assume those who developed the specifications for a product inadvertently omitted certain desirable features such as treating exposed metal for corrosion resistence or adding an inexpensive attachment which would simplify product maintenance. The supplier would have no incentive to add these improvements, even though treating exposed metal would add to the useful life of the product and incorporating the omitted attachment would lower its cost of operation.

The government buyer, unlike his industrial counterpart, is apparently not free to take his business elsewhere, even though in a situation like this one he should have that freedom. The supplier can insist that his firm has complied with the specifications provided and has acted in a fully responsible manner. Apparently, it is possible for suppliers in such situations to disclaim any responsibility for the limited serviceability of their product using the argument that responsibility does not extend beyond meeting the government's specifications.

The government buyer's usual recourse when faced with this circumstance is to rewrite the specifications to include the omitted features. Unless he or she can prove that a supplier has failed to meet to the letter the specifications provided, the government buyer has no leverage with which to force a supplier to interpret specifications in a manner favorable to the government. The procurement agency is obliged to accept delivery of the product and keep the supplier on the bidders list as a qualified vendor in good standing.

LEAD TIME CONTROL

Lead time for a business establishment is a factor both in determining the procurement costs of the firm and its ability to compete effectively. Consequently, a cardinal principle of industrial procurement is to give estimates of lead time the closest kind of scrutiny to assure that it is no longer than prudence can justify. Since the procurement cycle includes order processing in conformance with the most economical and timely procedures, it can be shortened for requisitioning departments by improved administrative scheduling or maintaining larger inventories of the needed materials.

The military services must and do carry sizeable inventories of many strategic items. However,

one may question whether or not the federal procurement process makes a sufficient distinction between strategic and nonstrategic materials. While the strategic items must be carried in inventory, there is no such requirement for nonstrategic items. Inventories of these latter materials are a matter of choice not necessity. This, too, raises the issue of efficiency, because it can be questioned whether or not inventories of nonstrategic materials could be more economically maintained in the nation's commercial distribution channels than in government warehouses.

Another aspect of the lead time issue which raises questions of efficiency is the use of government procurement as an instrument of socio-economic policy. The Armed Services Procurement Regulations and the Small Business Act express the intent of Congress that small business receive a fair share of the federal government's business and that special consideration be given to firms located in areas designated by the Labor Department as having a labor surplus. In the case of a requisition for a large quantity of nonstrategic items for which specifications are clear and bidder interest active, advertised bidding would be the required procedure. However, the total quantity requisitioned could not be solicited by IFB's because a portion of it would have to be set aside for later negotiation with small business and firms in labor surplus areas.

It is probable that two weeks would be needed to develop the IFB and determine the percentage of set asides. The bids probably would be in the hands of suppliers for at least a month, while a week or more would be needed to abstract the bids and select the tentative low bidders. Verifying the competency of those bidders who were successful but with whom the bidding agency had not had previous contact would no doubt require a week and preparation of contracts would probably take another week. This amounts to a lead time of 60 to 65 days, which in such circumstances is uneconomical by almost any standard one might wish to apply. It underscores the need to rethink government socioeconomic policies which impinge on purchasing. Such policies increase administrative expense and in some cases they increase prices. However, their worst side effect is the limitation they impose on use of buyers' judgment in selecting suppliers which frustrates efforts to discharge a basic purchasing responsibility.

ORGANIZATION

The energy situation and the growing list of commodities in short or uncertain supply have led management at many industrial enterprises to insist that engineering consult with purchasing before approving product specifications. The fallacy of permitting product specifications to be developed in the absence of expert opinion regarding material cost and availability is now widely recognized in the industrial sector. This is indicated by the number of firms in which purchasing participates in R & D, engineering, and new product planning committees as well as exercises a veto over any choice of suppliers that might be made by engineering.

The sheer size of the federal government makes it difficult to achieve the kind of working relationship between those responsible for purchasing and those responsible for product specification that is possible in the private sector. A particular buying agency may not be a part of the requisitioning agency upon whose orders it is required to act. As a result, it would be difficult to develop or sustain an effective liaison between agencies which write specifications or develop requisitions and those responsible for procurement. Nevertheless, the greater the extent to which buyers fail to participate in decisions which affect purchasing the more difficult it is to conduct purchasing at a high level of efficiency.

The reported handling of the federal data processing program appears to be an example of the kind of difficulties which arise from the detachment of purchasing from agencies responsible for specifications and standards. While the original intent of the data processing standards program was to reduce procurement costs by increasing competition, it was also expected to promote the effective use of data processing resources, including the interchange of equipment, computer programs, and data. However, as of July, 1977, the federal government reportedly owned or leased over 10,600 computers on which it was losing approximately $100 million annually due to the lack of hardware standards - a deficiency which good user-buyer interface could do much to alleviate. (3)

There are no doubt compelling reasons why the linkage between purchasing on the one hand and engineering and R & D (the chief developers of specifications and standards) on the other, which is growing so noticeably in private industry, would not be achievable in the federal government. Nevertheless, the clear advantage which a good working relationship between procurement and requesting agencies promise make the attempt to bring it about worth considerable effort.

A PARTING SHOT

Few would argue that government procurement agencies, particularly those at the federal level, suffer debilitating restrictions in their effort to raise the efficiency level at which their operations are conducted. Inflexible budgets, the difficulty of applying Life Cycle Costing on a wide scale, price disclosure requirements, the inability to apply leverage, mandatory procedures which elongate the procurement cycle, and a complex structure of bureaus and agencies which obstructs close liaison between requisitioning and procurement agencies represent formidable obstacles highly resistent to change. However, a look backward reveals that positive changes have been achieved which were not inspired by some national emergency.

The Armed Services Procurement Act and Public Law 152 which together established negotiation as an authorized procurement technique, the Truth in Negotiations Act which empowered procurement officers to require contractors with awards in excess of $100,000 to submit accurate and appropriate cost data, and the Brooks Act which authorized the data processing standards program all represent significant progress toward more efficient purchasing by government. Senate bill 5 sponsored by Senator Lawton Chiles (D., Fla.) and currently (March, 1980) in subcommittee would if enacted into law restrict sole-source purchases as well as authorize more alternative proposals. It would appear to give government procurement officers the option of using any of three acquisition methods - straight advertised bids, RFP's or a new, small purchase category for contracts under $100,000.

Although this legislation is not impressive in terms of its volume, it does reflect policies and practices the effectiveness of which has been demonstrated in the private sector and which are advocated in the standard purchasing literature. (4) There is good reason to believe that the efficiency level of government procurement can be substantially improved through the application of techniques and procedures developed and demonstrated in the industrial sector, and that present restrictions are not immune to modification. In an era in which the high cost of government is under scrutiny by groups representing a wide spectrum of political affiliation, the present time is clearly an auspicious one to confront the challenge of needed change.

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SIMPLIFYING CONTRACTS FOR COMMERCIAL SYSTEMS

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ABSTRACT

The Air Force has recognized many advantages in acquiring privately developed aircraft and support equipment, as opposed to special designed systems. The problem is how to get Government contracting requirements and procedures in harmony with marketplace practices in buying commercial products. It is a Government problem that needs to be resolved in order to achieve maximum benefits of Federal and DOD policy in Acquisition and Distribution of Commercial Products (ADCoP) (1).

DOD recognizes the benefits and difficulties in implementation of the "buy commercial" policy. It asked the military services to try alternative strategies in buying off-the-shelf items to help identify and solve ADCoP problems. (2) These "pilot purchases" have been useful but they were for consumable and other off-the-shelf products that do not involve the same kind of contracting and production problems as those normally encountered in acquisition and support of major systems. This paper presents the finding from a project that studied the Air Force contracting process in acquiring and supporting major commercially developed aircraft systems. Conclusions and recommendations resulting from the research indicate need to recognize business practices of the marketplace in acquisition directives by issuing separate commercial product guidelines on General Provisions, purchase specifications and contract administration.

THE PROBLEM

Congress established the Commission on Government Procurement a decade ago to examine Federal acquisition policies, procedures and practices for economy and effectiveness. The Commission report contained several recommendations to improve acquisition of major systems and commercial products. These recommendations required greater reliance on industrial solutions to mission needs and greater use of privately developed products. (3) The Commission also recommended establishment of an Office of Federal Procurement Policy (OFPP) as a focal point in the Executive Branch for acquisition policy and procedural guidelines. This OFPP was established by statute and it has issued policy directions for both major systems and commercial products. (4)

DOD revised DODD 5000.1 Major Systems Acquisition and issued 5000.37 Acquisition and Distribution of Commercial Products (ADCoP) in response to OFPP policy direction. It also established the Commercial Commodity Acquisition Program (CCAP) to help identify and resolve institutional and contracting problems in implementation of ADCoP. Most pilot purchases accomplished under this program have been for "off the shelf" consumable items. A few have been for durable goods. The lesson learned from these pilot cases is that ADCoP has been inhibited due to DOD organizational structures and unique government procurement procedures and practices. The DOD is revising the DAR to resolve problems. However, contract requirements for major commercial systems have not been addressed.

Except when special development is required to meet military mission needs, the Air Force has relied heavily on commercial aircraft and other privately developed equipment for many of its needs. It recognizes potential advantages of shorter acquisition lead time, lower price, simplified logistics and proven reliability of products privately developed for commercial sales. It has also encountered many difficulties in following Government directives that impose procedures and contract requirements differing significantly from commercial business practices of the marketplace. It has fielded these difficulties as they are encountered but recognizes that benefits in cost/schedule and administration can be achieved by revising Government contract requirements and procedures to more closely adhere to commercial business practices in the marketplace. In recognition of these problems and potential benefits, the Air Force Business Research Center sponsored a research project with Don Sowle Associates, Inc. to define the problems and recommend solutions.

METHODOLOGY

The research was conducted to determine which provisions and requirements imposed in Air Force acquisition and logistics support contracts for typical major commercial systems and products, not imposed in typical commercial sales contracts, have a cost and schedule impact and, where possible, the extent of the impact. Analyses were made to ascertain the necessity for these provisions and requirements and to develop

recommendations concerning their use in future Government contracts to buy commercially developed products. Specifically, the objectives of the study were to:

1. Examine current statutory and regulatory provisions and military requirements imposed in Government contracts for the acquisition of commercially developed products.

2. Describe and analyze the process and reasons for requests by both the Government and contractors for waivers and deviations to clauses, specifications, and requirements.

3. Compare Government and commercial management practices as related to the acquisition of commercially developed aircraft.

4. Estimate the cost, schedule, and administrative effects of Government contract terms, conditions and requirements which are not imposed in commercial contracts.

5. Provide suggested revisions to Government policies and practices within existing statutes and laws in contracting for commercially developed products.

6. Identify and explain those socio-economic and environmental statutes that impact the economical purchase of commercially developed products.

The baseline for the research was a case study of contracts for the KC-10 Advanced Tanker Cargo Aircraft System, the E-4 Advanced Airborne Command Post System and for C-9 Aeromedical Evacuation Aircraft logistics support. These contracts are for derivative of commercial aircraft, equipment and parts that are sold in a competitive commercial marketplace.

The study was limited to analysis of the contract terms, conditions, and requirements of the Statement of Work. The first step in conducting the study was the identification of data for detail analysis. After obtaining solicitation and acquisition documents, each page and paragraph were reviewed to identify those requirements having potential adverse impact on cost, schedule, or administrative burden. This identification was based on the experience and judgement of the researchers. These requirements were documented as data elements and classified in accordance with the study tasks for analysis.

Following the identification of data elements needing further investigation, the source of the requirement, i.e., specific statute, Executive Order, directive, regulation, etc., was identified to determine the intent of the source document. Supporting data was then gathered pertaining to compliance actions required and the accompanying cost in dollars, manhours, delays, etc. Data was gathered through visits to program offices and contractor's facilities. Final analysis of data elements was made and suggestions for policy changes developed.

Other efforts to identify the contractor's cost of doing business with the Government were reviewed for inputs concerning the development of such a methodology. In March 1979, Arthur Andersen and Co. reported on its study of the Cost of Government Regulation for the Business Roundtable. This study was directed at costs incurred in complying with the regulations of six Federal agencies other than DOD. The methodology derived from that study was not found to be applicable to costs of compliance with specific Government contractual requirements. Another study, by the Comptroller General of the United States, attempted to identify specific costs of doing business with the Government. The GAO study, initiated in July 1975, found that it "was most difficult for any methodological approach to try to capture many so-called indirect or non-recurring costs."

FINDINGS

Mandatory General Provisions Each of the acquisition and logistics support contracts studied contained approximately 100 General Provisions. (5) Additionally, about one third of the General Provisions were required to be flowed down to the subcontracts for Government acquisition and contract support. (6) Twenty-one of the provisions required for subcontract flowdown were socio-economic, environmental or national policy provisions which were required by law or Executive Order for all contracts and subcontracts over $10,000. (7)

The Federal procurement process has been used to an ever increasing degree as the vehicle for furthering national policy, primarily in the socio-economic area, through Federal statutes and Executive Orders. As a result, the number of mandatory terms and conditions required for DOD contracts continues to grow at a significant rate. (8) The Defense Acquisition Regulation (DAR) and its predecessor, the Armed Services Procurement Regulation (ASPR), were codified over the years for the acquisition of supplies and equipment developed and produced to military and Federal specifications. No distinction was made for general provisions that applied specifically to commercially developed products.

General Provisions are standard contract clauses (boilerplate) that are in addition to product-related objectives. Some of the clauses have been included to predetermine the rights of both contractual parties, particularly in the event of unplanned developments, such as the clauses for Changes, Variation in Quantity, Pricing Adjustments, etc. Other clauses establish the rights of the Government and have been standardized to assure fair treatment to all contractors, e.g., Data Requirements, Data Rights, Termination for Convenience of the Government, etc. However, a number of mandatory contract clauses are designed to achieve national socio-economic objectives, e.g., Small Business Subcontracting Program, Utilization of Minority Business Enterprises, Employment of the Handicapped, etc., or are included to protect selected segments of industry or foster the defense industrial base, e.g., Required Source for

Jewel Bearings, Required Source for Miniature and Instrument Ball Bearings, Preference for U.S. Flag Carriers, etc.

Socio-economic and industry protective clauses reflect worthwhile national objectives. However, when applied thru contractual means to purchases of off-the-shelf products which have already been produced, their effect is lost. (9) When these clauses are applied to the acquisition of aircraft and components that are being produced in the same production line with commercial aircraft, it is impractical to impose a special set of conditions for some of the items on the production line and not to others. (10)

The General Provisions studied in contracts for acquisition and logistics support of commercially developed aircraft reflected a major difference in Government and commercial practices. They created problems and an administrative burden for contractors in that each clause had to be evaluated for impact on commercial practices, most of them with legal counsel, and imposed on suppliers of commercial parts and components where flowdown was required.

Mandatory General Provisions were reluctantly accepted by prime contractors since there did not appear to be any alternative in selling their products to the Government. But they questioned application of many of provisions to commercial systems and components for "off-the-shelf" products for a few items in regular production. (11)

Historically, aircraft manufacturers maintain long term agreements with suppliers for materials, parts and components. (12) Most of these agreements are developed through competitive negotiation during the development phase of the commercial aircraft. Douglas, for example, had basic agreements with approximately 20 suppliers of major components and purchase agreements with about 170 suppliers of high-dollar value equipment for the DC-10. The components and equipment purchased under these agreements were level priced over the estimated program quantities. Non-recurring costs were amortized over agreed upon quantities. These agreements contained a provision that, in the event of sales of aircraft to the Government, an amendment to the agreement would be made to include the applicable provisions required to meet Douglas' obligations under the Government prime contract. Even with that provision, the Government clauses which were to be included in subcontracts required extensive negotiations with suppliers because of questionable applicability and administrative costs. The problems of negotiating Government required clauses with suppliers who did not have other Government business were more pronounced than with those who did. (12)

Both the Douglas DC-10 and the Boeing 747 aircraft required some modifications to convert them to the military KC-10 and E-4 systems respectively. Each system, therefore was a composite of the basic airplane and modifications. In view of this composition, component parts were identified as either peculiar or common items. Peculiar items were those required to convert the basic airplane to the military configuration while common items were standard to the basic airplane. All of the General Provisions of the prime contract required for flowdown had to be included in subcontracts for peculiar items. General Provisions were waived for subcontracts for common items except for clauses required by law or Executive Order. With this distinction, 21 of the 35 clauses were required to be included in subcontracts; even for common items. Based on the breakout of common and peculiar items, Douglas had to develop and negotiate with suppliers five different sets of terms and conditions, i.e., for component parts for the DC-10, KC-10 common, KC-10 peculiar, KC-10 support common items and KC-10 support peculiar items.(13)

The lack of decisiveness of the term "subcontract" especially in the context of common and peculiar parts, contributed to the flowdown problem. The definition of "subcontract" and "subcontractor" in DAR 7-103.1, Definitions, is "except as provided in this contract, the term 'subcontract' includes but is not limited to purchase orders, changes and/or modifications thereto." Other definitions of the term are found in various clauses and sections of the DAR. In these definitions the general inference is that a subcontract must be in direct support of the prime contract. This interpretation is not considered to be adequate for the acquisition of commercial systems manufactured for DOD incidental to and integrated with manufacturers' regular production. Douglas, for example, purchased parts and supplies for its commercial DC-10 production line. This common production line included aircraft that would be converted to military KC-10s. Since these parts and supplies were commingled, those to be incorporated in airplanes that would become KC-10s could not be discreetly identified. The lack of a definition of "subcontract" that clearly excludes purchases for inventory for the production line leads to problems of application.

Many problems in accomplishing subcontracts with suppliers of hardware for the KC-10 aircraft were due to lack of familiarity initially with Government contract requirements on the parts of Douglas commercial buyers who purchased DC-10 hardware.(14) To resolve these problems, a series of special training programs for those buyers were established by Douglas. The special training sessions for approximately 120 buyers, together with the cost of key personnel to develop training material and instruct, all buyers related to the acquisition of the KC-10, generated cost to Douglas. Because the cost of this activity was not specifically accounted for,it was difficult to arrive at a total cost impact although salaries and fringe benefits of the personnel involved was estimated by Douglas at $116,000.

The socio-economic, environmental and national policy clauses required by law or Executive Order to be included in subcontracts apply to the purchase of both common and peculiar items. Since these clauses are in addition to product-related objectives, their primary impact is one of administrative burden for both the prime and

subcontractors. They pertain to employment practices, subcontracting with small and minority business, record keeping, reporting, and similar actions which increase the cost of doing business. They increase management manhours to review, determine actions to be taken, develop special actions where required, negotiate subcontractor acceptance of terms and conditions for meeting Government contracts, and to participate in Government surveillance visits and audits. The objectives of these requirements are laudatory but their application and benefit in buying commercial systems and products is questionable.

Military Requirements of the Statement of Work Requirements of the Statement of Work reflected differences in the acquisition of the KC-10 and E-4 aircraft from normal commercial practices. A majority of these requirements, however, so closely paralleled commercial practices for the DC-10 and 747 aircraft that they caused no major problems in compliance. Therefore only those requirements that illustrate significant differences from commercial practices will be discussed in this section.

Most of the military specifications and standards included in the KC-10 and E-4 Statements of Work pertained to the modifications of the basic airplane. Management plans as well as other military requirements, on the other hand, encompassed the development and production of the complete aircraft system. The intent of the Government was to make maximum use of documentation available. (15) However, the contractors were required to comply with the criteria of listed military specifications and standards and to report in accordance with Data Item Descriptions (DID) as modified by the Contract Data Requirements List (CDRL).

The following facts and observations address specific requirements of the contract Statements of Work. While the impact of individual items may appear to be insignificant, together they created a significant impact on the contractor, increasing cost to deliver systems to the Air Force.

Aircraft Modifications Two different sets of conditions were applied to the acquisition of a single aircraft system, i.e., applications of commercial standards for the basic airplane and military standards for the modifications. Modifications to convert the DC-10 to the KC-10 were primarily for the installation of the aerial refueling subsystem and fuel storage cells. Since the KC-10 was estimated to be 88 percent common with the DC-10, the modifications were considered to be a relatively minor part of the total system. Likewise modifications to the 747 aircraft under the acquisition contract were primarily for installation of an in-flight refueling receptacle and navigator's station in the crew compartment and considered to be relatively minor. Conversely, the modifications to convert the 747 aircraft to the E-4 configuration pertaining to the accommodation of the communications, command and control (C^3) subsystem were considered to be major and were accomplished under separate contract.

Analyses of the acquisition programs for both aircraft systems, including modifications, surfaces the question of the most effective contract arrangement to accommodate modifications. The draft Federal Acquisition Regulation (FAR) defines a commercial-type product as a "commercial product modified with some Government peculiar physical change or addition and/or otherwise identified differently than its normal commercial counterpart." (16) No policy, however, has been established for the acquisition of commercial-type products nor has the amount of modification been established whereby a commercial product should no longer be considered a commercial-type contract.

Specifications, Standards and Data Item Description The management philosphy of the Air Force for the acquisition of the KC-10 and E-4 aircraft systems was to rely on FAA or commercial standards except when such standards did not meet Air Force needs. FAA or commercial standards emphasize safety requirements. Military standards also specify performance. When performance was a prime additional consideration, military standards were used. (17)

Using this approach, the Air Force was successful in limiting the number of military specifications and standards as contractual requirements, when compared to typical requirements for new military system development. For example, the Statement of Work for the KC-10 acquisition called out 20 different military specifications and standards; 10 were referenced for guidance and the remaining 10 were specific requirements. The 20 military specifications and standards contained in the Statement of Work for the KC-10 are compared to a nominal 200 military specifications and standards required for the new development of military aircraft weapons systems. In commercial practices, the contractor is required to develop aircraft in accordance with nine FAA specifications and standards.

The Air Force was also successful in limiting the data requirement for the acquisition of military derivative commercial aircraft compared to the requirements for a new military system development. Even so, the requirements for documentation and reporting exceeded that required in normal commercial practices. The Contract Data Requirements List for the KC-10 acquisition contained approximately 100 different data requirements. Although there were more than 100 data items on the list, some are repeated throughout the various phases of the program. The 100 different data items required for the KC-10 acquisition compare to an average of 300 different data items required for new military development. No data reporting requirements similar to DIDS are levied on the contractor by FAA or commercial customers although the contractor makes approximately 20 items of technical data available to both.

Management Plans The SOW for the KC-10 acquisition contract required the contractor to prepare and submit 19 management plans for Air Force approval. The Human Factors Test and Evaluation Plan was submitted as an annex to the System Test

and Evaluation Plan, and the Reliability and Maintainability Plans were combined, leaving a total of 17 management plans.

Military Specifications and Standards and AFSC Design Handbook were referenced for general intent and guidance for the preparation of management plans. The Air Force agreed to accept the contractor's format. However, the information required for each plan was specified by a Data Item Description (DID) as modified by the CDRL. This required considerable documentation to be assembled and delivered.

The contractor's management procedures were documented in a number of company handbooks and publications. They are annually reviewed by the FAA. Various functional groups within the company, i.e., engineering, pricing, scheduling, etc., each have their own specific procedures documented in company publications and directives. In preparing management plans which satisfy information requirements of the DIDs, the individual responsible for the plan had to collect information from a number of company source documents. Although the information required was available in some form, the integration of data into a management plans was <u>time consuming</u>.

The contractor's KC-10 program engineering group was responsible for the preparation of 15 management plans. The 15 plans consisted of over 7000 pages. The initial preparation of the 15 plans and the rework to obtain Air Force approval consumed over 7000 staffhours of effort on the part of the program engineering group. The total effort, including the hours required of management, illustration and publication personnel, required 10,000 staffhours. A number of additional, unrecorded hours were expended in reviewing and discussing the plans with Air Force personnel.

The Air Force rationale for requiring management plans was two-fold; the requirement to manage the expenditure of large amounts of appropriated dollars and the need for information to respond to inquiries from higher echelons of command and from Congress. (A program manager of a major program needs to be responsive to Headquarters Air Force and to the Office of Secretary of Defense.) The various review offices have interests in different aspects of acquisition. The program office is expected to answer many questions on any aspect of the program. Congressional interest requires that a program manager be knowledgeable of the details of the acquisition. He is expected to have a method of tracking contractor progress and of detecting and correcting problems before they become acute. These requirements of a program manager, particularly in the political environment of large acquisitions, are demanding. Such expectations motivated the KC-10 program manager to require management plans from the contractor.

Commercial customers do not usually require specific management plans covering the contractor's procedures for managing the development and production of an airplane. From the contractor's point of view, the requirement for management plans by the Air Force reflects excessive documentation and evaluation of the contractor's ability to manage a program. They cite the fact that they have successfully developed, produced, certified and flown a large number of airplanes of the commercial version.

The SOW for the E-4 acquisition (Phase 1A-1, Aircraft Portion) required seven management plans for approval. A comparison with the KC-10 acquisition is not applicable in view of the separate contract (in this case, a different contract) for the installation of the C^3 subsystems in the 747 aircraft. (18) The impact on the contractor, however, was of the same nature, i.e., additional administrative burden. The problems of preparing management plans for the E-4 program was compounded since the Air Force contracted with the Boeing aerospace organization who in turn dealt with the Boeing commercial airplane organization for the production of the basic airplane. (19)

<u>Configuration Management</u> The Air Force maintained control over the acquisition of the KC-10 and E-4 aircraft systems. The contracts required that configuration management plans comply with the criteria of MIL-STD-483 and that Engineering Change Proposals (ECP) be processed as described in the standard. Similar requirements were included in the Statement of Work for the KC-10 Logistics Support contract for changes after aircraft delivery.

Proposed changes that would effect aircraft specifications, requirements, price,delivery schedules, specified weight or performance, specified interchangeability requirements, maintenance or logistics support concepts, or required reidentification of spare parts or assemblies, were to be processed as Class I ECPs. Proposed changes that did not fall within Class I criteria (Class II changes) could be made without Air Force approval provided a Specification Change Notice was submitted to the Air Force concurrent with release of the change from engineering for agreement in classification.

The configuration for the KC-10 was based on the basic DC-10-30F specifications, changed to include the modifications required for the KC-10. Changes to the specifications during the development and production of the first article were required to be processed as either Class I or Class II ECPs. After the Predelivery Design Review, all changes were to be processed as Class I ECPs.

For the modification to the 747 aircraft in the E-4 program, the contractor was required to document the Product Configuration Identification for each configuration item with a product specification. Authentication of each product specification by the Air Force then established the product configuration baseline. All Class I changes to the Product Configuration Identification before the establishment of the baseline were to be processed as either a Class I or Class II ECPs for the E-4B aircraft. For both E-4 aircraft, Service Bulletins were to be processed as an ECP. (This requirement was eliminated for the KC-10).

Routine Class I changes (other than Emergency, Urgent, or Compatability Changes) proposed by the contractor required an Advanced Change/Study Notice (ACSN) to be submitted and approved by the Air Force before any effort could be started on the preparation of the ECP. The ACSN includes: an identification of the item affected; an explanation of the need for the change; and a technical description of the modification or study needed. The ACSN is prepared in sufficient detail to describe: the problem to be corrected; a listing of alternative ways to meet the need for change noting the desirability and cost estimates for each; and a cost estimate for development and production of the proposed change. With approval of the ACSN, the contractor is authorized to develop the ECP which provides detailed engineering data and drawings for evaluation. A not-to-exceed price and other information for contractual purposes are required with the ECP.

Processing time for a routine Class I or II ECP, including the submission of an ACSN, varies with the complexity of the change. The average processing time was three months. Other than the time and effort required for preparation and processing of documentation, the development of firm pricing prior to approval of the ECP and accomplishment of the change presents a problem. It is tantamount to establishing a fixed price for a development project where adequate coverage of contingencies must be assumed. In view of the unique Unit Price Matrix for the KC-10. It was particularly troublesome for Douglas to establish a firm fixed price for changes that would effect aircraft systems to be produced in the outyears.

The contractor maintains an organization responsible for implementing the requirements of configuration management using company developed, FAA approved practices. He prepares the configuration item specification audits. For commercial sales, Class II changes are determined by the producer and customers may or may not be notified, depending on the nature of the change. For proposed Class I engineering changes, customers are notified of the proposed change with adequate information on the advantages and estimated cost of the change to permit understanding on how the contractor will accomplish the change. A statement of interest is solicited. If most customers desire the change, the contractor incorporates it. (20)

Support Equipment The acquisition contracts for the KC-10 and E-4 aircraft required the contractor to perform analyses of operational and maintenance functions to identify requirements for support equipment (SE). From these analyses, a Support Equipment Recommendation Data (SERD) document was prepared for each requirement. The SERD documented the functional analysis. It provided data on cost of ownership, base of maintenance, human engineering analysis, useful life and technical description.

Using SERD information, the E-4 contractor was required to screen the Federal Stock Numbered SE or other military documented lists of support equipment for standard items in the USAF inventory that could be used as is or modified for peculiar E-4 support. Recommendations on which items should be CFE, GFE, or combination were then made to the procuring activity. The priority of selection was: (a) standard item or modifications of standard items in the USAF inventory, (b) commercial off-the-shelf or modified commercial items, and (c) as a last resort, new development. The Air Force evaluated the recommendations and made the final decisions, giving contractual authorization for those items to be developed or purchased.

A baseline listing of KC-10 peculiar support equipment, together with a SERD for each item including pricing data, was required by the RFP. The KC-10 contract required the contractor to submit a SERD, with pricing, for additional support items as the requirements are identified. The Air Force evaluated the SE requirement and screened the inventory for standard items in the USAF inventory. Only after new support equipment items were approved as a result of this process was the contractor authorized to proceed with detailed engineering design.

Computer Programs The SOW for the KC-10 contract required that each new computer program be managed as an individual configuration item in accordance with MIL-STD-483. For each new computer program, a development specification, a product specification, and a version description document (document for maintaining software) were to be submitted in accordance with the DIDs contained in the CDRL.

For the conversion of the DC-10-30F to the KC-10 configuration, only one new computer program was required, for the control of the Aerial Refueling Boom (ARB). After the computer program was developed and the required control of the boom demonstrated, the computer would be hardwired for operational use. This type of computer program was referred to as "firmware" and was used where no changes to the operational capability, once developed, was envisioned.

MIL-STD-483 applies to the configuration control of development and production of computer programs (software). Documentation required is necessary for the maintenance of the software. Because the computer program was hardwired into the computer and no computer program changes can be made without a redesign of the computer, it is questionable if software-type documentation was needed.

In commercial practice, the contractor prepares a Computer Software Quality Program Plan in accordance with FAA-STD-018 which outlines the process flow, validation of technical requirements, testing, evaluation criteria, design reviews, etc. For a computer program that is to be hardwired into the computer, sufficient documentation is prepared to authenticate the program.

Contract Work Breakdown Structure (CWBS) The KC-10 was being produced on a common DC-10 production line with KC-10 modifications being made on-line. It was estimated that the KC-10 will be approximately 88 percent common with the DC-10-30F. DC-10 aircraft were being produced at a rate of 41 aircraft per year, of which two will be KC-10's.

The contract required a CWBS for reporting schedule performance for the KC-10. A work breakdown structure is a contract and product-oriented family tree division of tasks. It organizes, defines, and graphically displays the product to be produced. It also defines the work to be accomplished on the contract to achieve the specified product. From the CWBS, the contractor established a Program Master Schedule, an Engineering Master Milestone Schedule, and a First Article Preproduction Schedule for the KC-10. (21) In view of the production strategy where the KC-10's are intermixed with the production of DC-10's, difficulty was experienced in establishing a CWBS which was meaningful in reporting schedule performance solely for the KC-10 aircraft.

Although the manhours expended in preparing a CWBS for the KC-10 were not specifically recorded, the contractor reported that an extraordinary amount of key personnel time was spent in developing CWBS data as required by the DCRL. The CWBS submitted by the contractor, was not being used by the Air Force for assessing KC-10 schedule performance. Other progress reporting information was used for that purpose. Commercial customers did not require such detailed scheduling information.

When the Air Force acquires commercially developed aircraft from a manufacturer's regular production, commingling precludes in-line production work packages identified by specific customer aircraft.

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations derived from the study of Air Force acquisition of commercial derivative aircraft, contract logistics support for those aircraft, and the acquisition of a major item of support equipment are summarized by major areas of interest.

1. Mandatory General Provisions One of the biggest drawbacks to the Government acquisition of commercial aircraft, aircraft modifications, and contract support is the practice of including a large number of general provisions in the solicitations and subsequent contracts. The general provisions are in addition to product-related objectives and create additional administrative burden on contractors, increasing their cost to produce. When applied to products which have already been produced for commercial counterparts (off-the-shelf) or to acquisition from regular production of which the Government purchases only a portion, their effect is questionable. Where they are required to be included in subcontracts for commercially produced items, flowdown is exceptionally difficult because of questionable applicability. Recognizing that many general provisions are required by law or Executive Order, it is recommended that:

- o DOD develop and obtain approval to include in DAR Section VII a special set of general provisions tailored to the acquisition of commercial systems and products and contract support for those systems and products.
- o Federal Acquisition Regulation Project Office (FARPO) include in FAR Part II, Acquisition and Distribution of Commercial Products, a definition of "subcontract" which clarifies the application of contract requirements to subcontracts for parts purchased for stock or regular production.

2. Military Requirements for the Statement of Work The Air Force practice in acquiring commercially developed aircraft and aircraft modifications is to apply FAA and established commercial standards to the basic airplane and military specifications and standards to the modifications. Documentation requirements, however, generally apply to the acquisition of the total system. The application of military requirements precludes the Government from obtaining aircraft at the most economical cost which could be accomplished by taking advantage of established commercial practices relative to commercially developed and proven aircraft. It is therefore recommended that:

- o Implementing directives for FAR Part 11 include guidelines for acquiring commercial-type products, where the cost of modifications represent less than 35 percent of the commercial aircraft price, using commercial practices and standards. If the cost of modifications exceed 35 percent of the price of the basic product, modifications should be segregated and contracted for separately.
- o Air Force eliminate the requirement for documenting company management practices in accordance with military data item descriptions for the acquisition of commercial systems.
- o For the case of acquisition of commercially developed aircraft with minor modifications, the manufacturer be allowed to retain control of the configuration up to the point of final configuration of the first article.
- o Air Force simplify procedures for processing requirements for, and evaluation of, support equipment.
- o Where computer programs are to be hardwired into the computer after test and evaluation, only that documentation necessary for assuring proper operation of the equipment be required.
- o Air Force eliminate the requirement for a Contract Work Breakdown Structure for the acquisition of commercial aircraft where production of aircraft for the Government is commingled with production of commercial counterparts.

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THE ROLE OF MARKETING COMMUNICATIONS IN ORGANIZATIONAL BUYING: IMPLICATIONS AND OPPORTUNITIES FOR FEDERAL PROCUREMENT PRACTICE

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ABSTRACT

This paper covers the role of Marketing Communications in both the organizational and federal procurement process. A brief exposition of the similarities and differences in the two buying processes is presented as background for more detailed discussion of the communications issues.

The paper is conceptual in nature based upon a review of prior research and literature as well as the author's experience as a consultant in industrial firms that supply products to both industrial buyers and the federal government.

One of the important differences between the organizational and federal buying decisions is the constraints placed upon the interaction between prospective vendors and the contracting agency. The author's hypothesis results in a sub-optimum purchase performance by federal buyers.

All to often researchers on a particular discipline tend to develop a narrow, highly constrained view of their world of interest. This is no less true of researchers in marketing than it is of those in federal procurement. It is the recognition that developments in one area of study could have meaning and applicability beyond their native fields that has led to the explorations presented in this paper. An important contribution to this crossfertilization effort has already been made through the establishment of a session on an Organizational Buying as part of this symposium.

Under present federal procurement regulations, the manner in which a contracting officer may interact with a prospective vendor is specifically prescribed and limited. Conversely other organizational buyers have fewer constraints and limits placed on the manner and type of communication between themselves and prospective vendors. The author believes that although these constraints placed on Federal buyers have a legitimate purpose, they may, however, result in suboptimized purchase performance for the contracting agency. This paper which seeks to explore this issue conceptually and present suggestions for empirical research into the author's premise is presented in four sections. The first is a brief overview of organizational buying and federal buying. The second is a discussion of the role of marketing communications in organizational buying as seen through the marketing literature. The third is a description of the role of communications in the federal procurement process with comparisons to organizational buying where appropriate. The final portion covers comments and observations about the effects of any differences as well as suggestions for future research which could be useful vehicles for further exploration of the author's hypothesis.

OVERVIEW OF ORGANIZATIONAL BUYING AND FEDERAL BUYING

Before we can explore the role of communications from the perspectives of the organizational and federal buyer, it is necessary to first define a concept of organizational buying behavior, as a frame of reference. Moriarity and Galper (1) in their review have indentified four interacting building blocks that make-up the cornerstones of any general conceptualization of organizational buying behavior. These are the buying process, which describes the steps through which an organization proceeds in arriving at a particular buying decision; buying classification, which identifies the type of buying decision involved; the buying determinants, which defines personal, interpersonal, organizational and environmental factors that influence the buying decision; and the information sources, which call out the personal and impersonal sources of information used to make buying decisions. It is this last element that will be explored in

detail in this paper as well as some of the interactions between information sources and the other building blocks.

Williams (2) in another paper presented in this symposium has compared organizational buying with federal buying. He has identified two general areas of buying practice where there are close parallels between organizational and federal purchasing. The first involves the buying process and the second concerns the buying classes.

Williams has also recognized that there are important differences between these two buying environments. He points out that these differences, stem from one common and dominant factor--the legal requirements of federal procurement. These requirements limit to varying degrees the range of actions available to federal contracting officers.

In addition the procurement activity must be undertaken in an open and public manner that facilitates review of the results by the congress, competing companies, and the general public.

With this as a background, let us now explore the role of communications in each of these environments.

ROLE OF COMMUNICATIONS ORGANIZATIONAL BUYING

The research that has been conducted on the information needs of organizational buyers has clustered around three basic questions.

1. How much information do industrial buyers and influencers use in making purchasing decisions?

2. What sources of information do industrial buyers and influencers use in making buying decisions?

3. What specific types of information do they use in these purchase decisions?

Quantity of Information

Faris (2) provided a valuable conceptual overview to the first issue. His research indicated that the information needs of organizational buyers and their willingness to expend effort to obtain and utilize information on alternative products is a function of the type of buying decision. He identified three broad categories of purchase decisions: new task, modified rebuy, and straight rebuy. New task decisions, which are the most complex and identified with a high degree of perceived risk, have the greatest information needs. Significant time and attention is devoted to information gathering for these decisions. Straight rebuys, by contrast, receive little or no new information input. Harding (4) reinforced this view, when he found that in 70% of the purchase decisions he studied, inertia was the most powerful purchasing influence. In these cases no appreciable effort was expended to get new information on alternative products.

Saleh et al (5) also supported this position in the study of motor transportation services. In the authors' words:

> "Our findings strongly suggest that most traffic managers rely on past experience as their major source of information in searching the market for a motor carrier. As a matter of fact, the majority of purchases made by shippers do not involve external search." "... in purchasing motor carrier services, the respondents indicated that the selection of a motor carrier was <u>usually</u> considered a routine decision."

Cardozo and Cagley (6) analyzed both high and low risk buying decisions and found that more information (number of bid solicitations) was sought in high risk purchases than in low. This finding confirms Faris' results for high risk (new buy) situations.

From another perspective Cardozo (7) points out that differences in purchasing strategy employed by buyers results in very different levels of information sought and used in the purchase decision. Two strategies are identified. The "sequential evaluation" approach involves each present suppliers, in sequence, receiving a first refusal opportunity on an informal basis before any new vendor is considered; "simultaneous scanning," on the other hand, opens the procurement opportunity to both new and existing suppliers at the same time through formal bidding procedures. Clearly more information is sought in the "simultaneous scanning" strategy.

The employment of risk-reducing strategies in purchase decision was also evaluated by Sweeney, Mathews and Wilson (8). They asked purchasing managers to rate their probable use of various strategies in a hypothetical purchase of electronic components for a manufacturer of TV sets. Two of the four strategic constructs observed, involved information

seeking behavior; one information set was derived directly from the seller (e. g., plant visits, top management commitments and the other from indirect sources (e.g. buyers in other companies, published information).

In summary, we can conclude that the amount of information sought and therefore needed in a particular buying situation is directly related to the newness of the purchase task and/or the amount of risk perceived by the buyer. Purchasing officers making higher risk decisions should be encouraged to be aggressive information gatherers.

Sources of Information

Industrial buyers receive the information they require for purchase decisions from a variety of sources. These have generally been divided into two broad categories; personal and impersonal sources. Included in the first are the manufacturer's salesmen, individuals in the buying firm, and individuals in other firms. The second group consists of product literature, product samples, trade journal articles, trade journal advertising as well as business and news magazine advertising. Two other specific forms of communication-trade show and technical proposals-appear to be hybrids and have been classified in both groups by different researchers, as will be noted below. I consider them both to be personal information sources, since the message content in both cases can be tailored to the particular needs of a specific buyer, even though the delivery may not be in person.

The research undertaken to date in this area appears to address three general issues.

1. What is the importance of various types of communications in the industrial buying/adoption process?

2. What, if any, are the differences in importance of each type of communications at each stage of the process?

3. What is the usefulness and credibility of each source of information as perceived by industrial buyers?

These questions have been addressed by researchers, studying diffusion of innovation in industrial firms. Some of the relevant work is noted below.

Using a three stage adaptation of Roger's classic adoption model as their process, Ozanne and Churchill (9) found that in the purchase of capital equipment (automatic machine tools) personal sources of information i.e. supplier and distributor salesmen were most important in the early stages of the process. Impersonal sources (technical proposals and price quotations) were most significant at the third (evaluation) stage. Advertising and promotion were meaningful only in the first two stages, (awareness and interest) and even then they were second in importance to manufacturer's salesmen.

Webster's studies (10, 11, 12) which investigated both formal and informal communications in industrial markets, supported Ozanne and Churchill's view of the importance of trade advertising at the awareness stage. He also found that personal sources, manufacturers salesmen and the like, became very important at the evaluation stage.

Martilla (13) on the other hand disagreed with Ozanne and Churchill's definition of technical proposals as impersonal communications. He claimed that since these are messages that are tailored to the individual buyer rather than standardized messages they should be viewed as personal communications.

Martilla's findings on paper buying practices indicate that impersonal sources (advertising, product literature etc.) and personal sources of information are of approximately equal importance in the early stages of the adoption process. Personal sources, including other persons within the buying firm and individuals in other firms, become dominant at the later stages. In these areas he is in accord with the other researchers.

Baker and Parkinson (14) looked at the information source issue from the perspective of different adopter categories (early, middle, and late). They found only one significant difference in utility of information across adopter groups. Early adopters considered members of their own firm to be much more valuable source. The authors draw another conclusion about this finding, as it relates to perceived risk. Early adopters were found to have a higher risk perception of the earth moving equipment studied than later adopters. They speculate that the internal consultation was a basic risk reducing strategy, as had been suggested earlier in the paper.

These findings were further corroborated in a study by Schiffman et al (15) which serves as a good summary of information sources and their importance in the buying process. His findings are as follows:

1. Mass communication is more important in the initial stages of the buying process -- primarily the awareness stage.

2. Personal communication becomes increasingly important as the buying organization progresses from awareness to adoption.

3. There are two dimensions of personal communication -- formal and informal.

4. As the process proceeds, the buying organization shifts from external sources to internal informal sources.

5. Opinion leaders within the organization play an important role as informal sources of communication (word-of mouth).

6. Opinion leaders tend to have more exposure to external channels of communication -- specifically trade journals.

7. Opinion leaders have greater interaction with other professionals outside their organizations in both information seeking and advice giving roles than non-leaders.

So far, these studies have emphasized the importance of different information sources at different stages in the buying process. There is the additional dimension of source credibility and usefulness in the decision process, which was researched by Kelly and Hensel (16). They studied a variety of organizations, which were considering the purchase of offset presses, and confirmed three frequently stated hypothesis about the credibility and usefulness of information sources.

1. Personal sources are more credible and useful than non-personal sources.

2. Non-commercial sources are more credible and useful than commercial sources

3. Non mass media sources are more credible and useful than mass media sources.

Buyers and influencers involved in purchasing actions use many sources of information to arrive at buying decisions. Personal sources of information whether internal or external, formal or informal become increasingly important as the buyer approaches the purchase/adoption decision. Ready access to those individuals who can provide knowledge and insight to the buyer would appear to represent an extremely valuable attribute pointing toward more effective purchasing decisions.

Information Content

The third major information issue from the buyer's perspective is the specific information needed and sought by the buyer. Lehman and Cardoza (17) take a broad perspective, looking at the relative value of product versus company data. They reported from their purchasing experiments with professional buyers and middle managers, that institutional advertising was more effective than product advertising along a number of key action and attitude dimensions (e.g., willingness to solicit bids, interest in firm as future supplier, belief about supplier's dependability and product quality). The authors suggest that detailed product information can be obtained from other more appropriate sources (e.g., salesmen, samples, and catalogues). This approach implies three things-1) that buyers have needs for differing kinds of information, 2) that there is a specific role that each type of communication can play best in the total information spectrum, and 3) that constraints in the access to all forms of communications may limit the buyers knowledge of alternative offerings and thereby reduce the effectiveness of the buying decision.

A pilot study of physician's selection of testing labs (Wind, 18) used conjoint analysis to determine the criteria used in this decision and their importance, comparing the results to another commonly used measurement approach. The focus of the study was clearly methodological but the substantive issue of differing information needs was also evident in the decision to apply this multi-attribute technique to an organizational buying decision.

The broad view presented in these studies essentially oversimplifies the information content issue, since it does not address the specific information needs of the individual members of the buying center.

The concept that industrial buying decisions take place within the context of a buying center (Robinson, Faris and Wind, 19; Webster and Wind, 20) has been widely accepted. The buying center or decision making unit consists of those individuals within the organization that participate in, or contribute to the buying decision. This recognition, that others, in addition to the purchasing agent, are significant influences in the purchasing process, raises very important communications issues that are only beginning to be addressed.

McLeer (21) in his research in the

construction industry takes an important step in approaching this question. He investigated the distinction in information requirements and sources between buyers and specifiers of building products. His research evaluates the roles of both personal selling (by manufacturers and distributors) and advertising (message content as well as media) in the communications process. His main theme, confirmed by his research, is that building product manufacturers do not know what information is important to which members of the decision making unit. He concludes, therefore, that manufacturers waste a large part of their advertising and personal selling investment.

Kiser, Rao, and Rao (22) also investigated differences in vendor attribute importance between purchasing and non-purchasing executives involved in buying decisions. The most consistent differences in perception between purchasing agents and other executives were found on economic-financial attributes. Also, decisions involving special products revealed more differences in attribute perception than those involving standard products.

Choffray and Lilien (23, 24, 25), also recognizing the significance of the buying center in purchasing decisions, have developed and tested a promising methodology and measurement procedure for determining the composition of the buying center and the evaluation criteria (information needs) of each of its members. In the assessment of the potential adoption of solar air-conditioning, the data revealed significant differences in the criteria used by each member of the buying center (production engineers, corporate engineers, plant managers, top managers and HVAC consultants).

The specific information required by a buyer or influencer is a function of the criteria used by that individual in making a purchase decision. Not all members of the decision-making unit use the same evaluation criteria or even give the same weight to criteria which may be common. In order to facilitate an effective decision-making process, participants in a decision making unit should have access to a wide range of information from a variety of sources.

Before moving ahead into the discussion of the role of communication in federal buying it is useful to summarize a few key conclusions drawn from the buyer behavior zone of research.

1. The quantity of information sought by buyers and the amount of effort expended to obtain it appears to be directly related to the complexity or newness (degree of perceived risk) associated with the purchase decision. Since most organizational purchases are of a rebuy or routine nature, buyers seek out relatively little information relying primarily on past experience with known suppliers. This pattern of behavior is clearly advantageous to the "in" supplier and undoubtedly explains in large measure the inertia and "carryover effects" observed in organizational buying.

2. In new or complex purchase decisions, where extensive information is sought, personal sources of information (salesmen, other buyers/users company personnel) are important throughout the buying process. Impersonal sources (catalogues, brochures, trade advertising, etc.) play a significant role in the early steps of the process, but diminish in importance as the decision making reaches a final conclusion.

3. The specific data sought or needed by a buyer will vary with the criteria that he uses in arriving at a product or source selection decision. Early research into the question of buying criteria tended to focus on the purchasing agent, as representing the whole organization. Recent conceptual and empirical studies have demonstrated that this is far too narrow and can, in fact be misleading. It is now clear that any research into organizational purchasing decisions must specifically account for the evaluation criteria of each member of the buying center. Some promising measurement and analytical methods have been developed recently to identify the members of the buying center and to ascertain their decision criteria. Continued progress in this area is a vital link to the further exploration of organizational buying and its implications for communications strategy.

ROLE OF COMMUNICATIONS - FEDERAL BUYING

Texts and other published material (26, 27, 28,) designed to assist businesses in the successful pursuit of government contracts identify and prescribe the appropriate use of the many forms of marketing communications. As might be expected a great deal of emphasis is given to personal selling activities involving direct contact with the various buying influences in the particular purchase decision. Media advertising, catalogues, directory listings, publicity and other

impersonal forms of communications serve to create awareness and knowledge of both the company and its products, among prospective users and influencers.

It is further pointed out that the amount of information sought by federal contracting officers is dependent on the class of purchase. Non developmental purchases (rebuys) may be made from blanket agreements or solicitations made from well established bidders lists, eliminating the need for any significant amount of new information. Furthermore, prior experience with suppliers is also an important factor in the buying decision. In contrast, new developments (New Tasks) involve buyers and contracting officers in extensive information gathering as to sources, products, specifications, prices, availability and the like. In fact, OMB Circular A-109 encourages the flow of information between the contracting agency and perspective suppliers, particularly in the initial stage of the systems acquisition process. Among the intents of this policy are to foster creativity in the development of major systems and to increase competition between design approaches and among suppliers. In spite of its acknowledged benefits, this procurement policy has had an uneven record of implementation to date.

Perhaps the most interesting perspective on the role of marketing communications concerns the importance of various forms of communications through the several stages of the buying process. It appears that both personal and impersonal forms of communication are used by federal buyers in the initial stages (Needs and Funding, and Planning). Impersonal communications (advertising, catalogues etc.) asist in assembling bidders lists, and personal communications (personal selling) play a vital role in the development of systems concepts, specifications and the terms of solicitation. These activities should increase as OMB Circular A-109 is more fully implemented. To this point in the process the similarities to general organizational purchasing are quite strong. In the solicitation stage the two buying processes begin to reveal some important differences. Communications with suppliers personnel still take place in both domains, however in federal purchasing this interaction becomes more limited. It is essentially in the form of clarification of the specifications, as well as the terms and conditions of the solicitation and not a vehicle for modifying the Request for Proposal (RFP) to facilitate the sellers' response. In organizational buying the latter is still possible at this stage.

At this point in the process governmental buying and industrial buying sharply diverge. Federal buying procedures with respect to communications become extremely formal and structured, limiting the interaction between the perspective sources and the buying influences to the documentation contained in the solicitation and the bids or proposals submitted.

In addition bids must be rejected for procedural failures i.e. late submission, incomplete documentation, or a proposed exception to the terms and conditions of the solicitation. Furthermore, in those instances where an evaluation of a complex proposal is required before selection of a vendor, the offering companies are not permitted on their own initiative to communicate with the individuals making such an evaluation in order to clarify, expand upon or otherwise explain the proposal. Some formal written communication may take place during this period, but only if specifically requested by the contracting officer. With exception of negotiated contracts the communication between the government buyer and prospective suppliers becomes increasingly restricted form the time a formal solicitation is promulgated until an award is made.

In industrial buying the personal interaction continues beyond this point in a much less formal manner with a high degree of flexibility still remaining and many opportunities to modify the requirements. Organizational buyers, in general, are free to accept, consider, and award contracts on bids or proposals that do not conform precisely to the solicitation. In this manner the industrial buyer preserves his options longer and is in a position to respond to unique buying opportunities that may occur due to changes in the supply environment. One form of communication - informal personal communication (word of mouth) - is quite significant in organizational buying. It is not entirely clear to this author the extent to which this form of information flow is utilized or encouraged within the federal procurement process. A-109 seems to provide some support to such actions as noted below.

"Agencies are encouraged to work with each other to foster technology transfer, prevent unwarranted duplication of technological efforts, reduce systems costs, provide standardization and help create and maintain a competitive environment for an acquisition."

This still leaves open a question as to the extent to which contracting officers seek information about abilities and qualifications of potential suppliers from non-government sources.

COMMENTS OBSERVATIONS AND POSSIBLE RESEARCH

From the preceeding discussion, there are a number of observations that can be made.

1. There are many parallels between organizational buying and federal buying with respect to the availability and use of marketing communications.

2. A body of knowledge has developed and is expanding on the subject within the marketing literature. It could also prove useful to researchers and policy makers within the federal procurement domain.

3. There is a strong movement in federal procurement policy (OMB Circular A-109) to increase the information flow between government buyers and suppliers, particularly at the front end of major systems procurement programs.

4. There are some important differences between organizational buying and federal buying regarding the access to marketing communications. These are particularly observed in the latter stages of the buying process, when federal buying policy creates a constrained communications environment that could result in a less satisfactory purchase performance.

Some possibilities as to the source of this reduced performance:

1. Rejection of attractive bids or proposals on procedural/technical grounds.

2. Less competition as a result of fewer bidders, created by

   a. complex procedures and paperwork
   b. exposure of bids to competitive/public scrutiny
   c. inability of small companies to manage the entire order.
   d. inability to get modification of technical points.
   e. inability to interact directly with the prospective user.

Three areas of possible research would appear to be productive:

1. To study in detail the information sources used by federal buyers in both routine purchases and new buys to determine more sharply the similarities and differences to organizational buying. Research procedures and methodologies similar to those employed in organizational buying would be employed to facilitate comparisons.

2. Comparative buying study between government and industry on a number of commodities purchased by both to determine whether federal procurement policies and practices lend to better or poorer purchase performance.

3. Undertake a buying experiment in which certain commodities would be acquired under modified (more flexible with respect to information sources) purchase procedures. The experiment would be limited to a particular region or department for a limited time. Comparisons of buying performance would be made with other regions/departments following current procedures. Any policy modifications employed would have to be feasible of large scale implementation.

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SIGNIFICANT SIMILARITIES AND DIFFERENCES BETWEEN FEDERAL AND OTHER ORGANIZATIONAL BUYING

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US Army Procurement Research Office

ABSTRACT

Federal buyers have historically seen themselves as unique. Evidence of this belief is the non-reference of general organizational buying practice, text and research in federal buying policy and research. Yet the two buying processes and the things bought through them can be shown to be very similar. Moreover, there are advantages for the federal buying community in identifying itself as part of organizational buying: access to knowledge of a much larger group, access to a much broader body of literature, and access to more research findings. Many federal programs (e.g., "buying commercial," "contracting out," and the use of non-restrictive specifications) are already taking the federal buyer closer to the non-federal buyer's environment. The federal procurement researcher has a responsibility to facilitate the pooling of the two bodies of buying knowledge.

Federal and in particular Department of Defense buying has often taken on a mystique to both those inside and outside the government. The large amounts of money, the complex procedures, and the seemingly endless paperwork involved tend to overwhelm observers and lead them to identify federal buying as a unique process.

But is it? Organizational buying is a respected field of study in marketing. It deals with the buying practices of any general organization. In recent years this particular area has received a great amount of emphasis. One author (1) recently stated he had located more than a thousand references in the form of books, articles, commentaries, and trade publications on the topic of organizational-industrial buyer behavior. Federal buyers do not tend, however, to take advantage of this potential source. Buying policy and buying policy changes normally do not reference non-federal buying practices or literature. Federal buying studies, courses, and conferences (2) rarely build on the work of nonfederal buying practitioners and researchers.

This paper will argue that federal buying is actually a special case of organizational buying and that acknowledging this association can result in great benefit to the federal buying community.

Comparison of the Two Processes. The first question is whether federal buying is close enough in concept and method to general organizational buying to be able to usefully generalize from one area to another. Let us compare the two processes and isolate similarities and differences in order to make that judgement.

Figure 1 shows the general steps of federal and organizational buying procedures.

ORGANIZATIONAL (3)	FEDERAL (4)
Recognition of Need	Needs and funding
Description of Need	Planning
	Solicitation
Selection of Sources	Selection
Ascertaining Price	Negotiations
Placing Order	Award
Follow up of Order	Contract Administration
(Ref: Westing et al, 1969)	(Ref: Federal Procurement Commission, 1972)

Figure 1
Comparison of Buying Procedures

The steps by different names say virtually the same thing. The organization perceives a need, plans to satisfy it, and describes it to the field. A source is selected. A price is negotiated (or low bid price is accepted). An agreement is made with the contractor. The buying organization insures that the agreement is carried out. The steps are generically the same at face.

Figure 2 shows the types of buys federal and general organizational buyers are involved in.

ORGANIZATIONAL (5)	FEDERAL (6)
Rebuy	Nondevelopmental (commercial, existing Government system)
Modified Rebuy	Modified Nondevelopmental; Product Improvement (of existing Government System)
New Task	
Technologically complex	New development
New to the firm	Nondevelopmental
New use	Nondevelopmental
(Ref: Robinson et al, 1967 and Lawyer, 1973)	(Ref: Based on Commission on Federal Procurement, 1972 and A-109 Circular).

Figure 2
Comparison of Items Purchased

Here the comparison requires a little more effort, but again the similarity is there. Both groups buy either a repetition of what has been bought before, a variation of what has been bought before, or something that has not been bought before.

It can be seen that although the steps and types of buys are worded a little differently, basically federal government and general organizational buyers do the same kinds of things. Yet, as mentioned earlier, there are marked differences in the actual exercise of these steps. One source (7) for example, lists a number of major observable differences: (1) typically the federal buys are larger, (2) there are more legal requirements in the federal sector, (3) there are numerous specialists and watchdogs to insure compliance with these requirements, (4) in the public sector, buyers go to greater lengths (e.g., Commerce Business Daily) to find sellers, (5) in the public sector, sellers can appeal buyer decisions, (6) much of the government market is monopsonistic, one buyer, and risky to the seller because there are no alternative buyers, (7) the public nature of the federal procurement process may expose a bidder's technology to other firms (8) the government buyer may have to forego the most "efficient" buy in order to pursue other government objectives such as maximizing contract awards to disadvantaged contractors, (9) those who have buying decision responsibilities are more numerous in the government and are wider spread. For example, high level funding decisions for a buy are in the Congress; a selection decision may be in the Executive Branch.

Although many differences are shown here (and there are others), the one constraint that appears to be dominant and is, in fact, the basis for most of the differences, is that of legal requirement. The federal buyer is using everybody's money and is buying things in the name of everybody. This requires that every action be just, equitable, visible, and answerable to every citizen. These requirements constrain every government buyer to a narrow range of detailed techniques clearly visible to all. The organizational buyer is using private sector money. He (or she) is buying for his firm and is limited in technique only by his boss, his conscience, the Uniform Commercial Code (relatively general in nature), and antitrust law.

This analysis would indicate that the federal buyer and the general organizational buyer are involved in the same process (basic steps and types of buys) but that the federal buyer can use only a subset of the techniques available to the organizational buyer. Consequently while the organizational buyer may send out solicitations to all qualified sellers, as the government does, he does not have to and usually does not. While he may have firms sequentially bidding against each other (a strictly forbidden practice in the federal government called auctioning) he may ask for formal one-time submission of bids, as the government does. Similarly, one could go through each buying step and show the basic technique the government must use and alternatives available to the organizational buyer.

The Federal Buyer as Organizational Buyer. Now that it has been shown that the buying processes are basically the same and buying techniques may or may not be, the question remains whether it is useful to classify federal buying as a special case of general organizational buying. In fact, this classification has already been made in many areas. In making routine and less complex buys, for example, many buyers of the public and private sector use very similar techniques and may well consider themselves brethren (e.g., large mutual membership in the National Association of Purchasing Managers).

The government movement to "go commercial" (8) will inevitably bring federal and non-government buying closer in approach anyway. With this movement, the government will phase out many government specifications and buy more commercial items. Unique federal buys will dwindle.

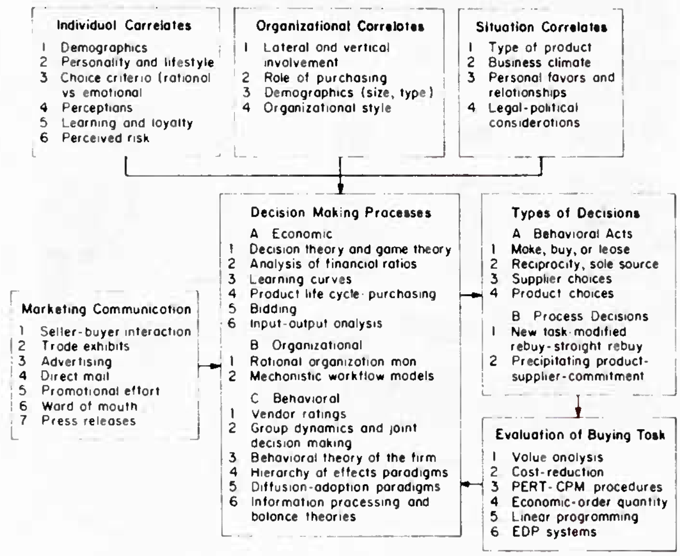
While there are 190,000 total organizational buyers (9) in the US, there are 60,000 federal buyers. (10). There is an opportunity for this smaller group to learn from the potentially larger pool of ideas of the larger group.

But most importantly, by considering federal buying as organizational buying, both federal buying practitioners and researchers can then broaden their horizons and gain more insight by exposure to the large body of organizational buying literature. There are a number of organizational buying texts that contain buying tips that could fall within the federal buying constraints, and add to a federal buyer's repertoire, and indeed some authors are linking up the two processes in their texts. (11) The organizational buying research could also be useful.

Sheth (12) has done one comprehensive summary of this work that should give an idea of the potential contribution this research could make to federal

buying.

1. Types of buying decisions
2. Evaluation of the buying task
3. Decision making process underlying buying decisions
4. Marketing communications and their influence on the decision making process
5. Impact of individual decision maker's characteristics on the decision making process
6. Impact of organizational characteristics on the decision making process
7. Impact of specific purchase situation characteristics on the decision making process



[Source: Sheth, J.N., Consumer and Industrial Buying Behavior]

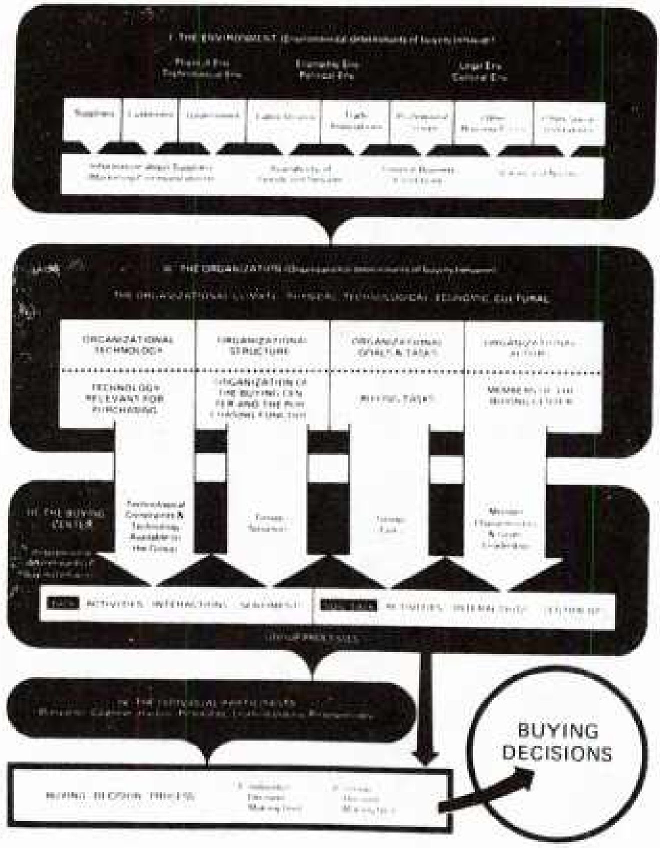
Figure 3
Categories of Organizational Buying Research

Note the generic nature of the seven topics. They could as easily apply to the federal as other organizational situations. Of the types of studies under the topics, probably only "loyalty," "personal favors," and "reciprocity" could be strictly ruled out as being useful to the federal buyer. All the rest have potential, although individual studies would, of course, have to be evaluated for relevance.

A prominent example of a marketing study that transcends any federal-general organizational buying differences is the Webster-Wind work (13) describing a general model for understanding organizational buying (Figure 4). Looking at the factors affecting the buying decision, a federal buyer might be struck upon reflection that these are the factors relevant to his typical decisions. Federal buying management could well use this model to analyze the behavior of an individual organization or to attempt to explain differences among organizations.

In like manner, one could show the potential relevance for organizational studies on topics such as bidding (14) and marketing communication effects (15) for federal buying.

This paper has compared the federal buying process and the general organizational buying process and then pointed out constraints peculiar to federal buying. Ultimately the paper attempted to show that federal buying is a special case of organizational buying, i.e., a kind of buying constrained to a certain set of techniques, and that much of the organizational buying literature and practices described can be useful for the federal buyer. Indeed, today's federal programs to "buy commercial," "contract out," use non-restrictive specifications, and so on compel us to recognize a closing gap between federal and other organizational buying. It now behooves both groups to take advantage of the cumulative knowledge of the other. This forum has a responsibility to exchange research findings between organizational buyers of all stripes.



Source: From Frederick E. Webster, Jr. and Yoram Wind, "A General Model for Understanding Organizational Buying Behavior," *Journal of Marketing* 36 (April 1972) 12–19.

Figure 4
A Model of Organizational Buying Behavior

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CONCEPTUALIZING THE ACQUISITION PROCESS OF ORGANIZATIONS: Approaches and Strategies

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ABSTRACT

The purpose of this article is (1) to organize a presentation of the various "schools of thought" concerning conceptual models of the acquisition process of organizations, (2) to develop a managerial perspective behind some of the models from the viewpoint of both the marketer and the acquisition practitioner, and (3) to present the emerging strategic management approach to the acquisition process, with emphasis upon strategic management of resource market relationships with implications for acquisition managers. This purpose is to provide for a discussion and research integration of widely diverse approaches to acquisition modeling for the purpose of synthesis for DOD researchers and managers.

PERCEPTUAL APPROACHES

The story is sometimes told of a group of blind persons attempting to describe an elephant based upon his/her own experience gained by feeling one portion of the animal's body--the trunk, ear, leg, or side. Each presented a different concept due to lacking perceptual skills and inappropriate research design. Such a perceptual bias might also come from a report by a vertabrate anatomist, a cultural historian, or even a Disney cartoonist focusing on one or more attribute. Perhaps some Ph.D. dissertation proves that elephants do forget and they are not afraid of mice.

When one approaches a review of various attempts to conceptualize and model organizational buying behavior--or acquisition processes as one school calls it-- he sees a similar perceptual myopia. However, differences which occur are not due largely to research ineptitude, but to different purposes of the authors. A major task given the author by DOD Symposium organizers was to bring into play a review of various academic/management approaches to model this process in contrast with the approaches being made within DOD. However, within the page limitations of this article, such a review places a large responsibility upon the reader, since the article can merely organize the work and note important bibliographical references. A limited bibliography is found in the article, and a more extensive one is available from the author at the conference or by writing him at his host institution in Provo, Utah 84602.

There are five major schools of thought concerning this process, each with its own set of conceptual literature--though incomplete:

Organizational Theorist

This school focuses on organizational decision-making, on roles and role conflict, information flow, the dynamics of relationships, risk perception and reduction, inter and intraorganizational functioning processes within the acquisition/marketing relationship.

Managerial Theorist

This school examines the management process used within the organization, with emphasis on goal setting and achievement, performance evaluation, structure of decision-making units, authority relationships, situational task differences, external and internal environmental pressures, and acquisition as part of the larger corporate process.

Psychologist/Human Behaviorist

This school looks inside the acquisition manager and influencer's head for motives, perceptual fears and biases, career and personal aspirations, emotion, learning, professional competencies, and coping with an often ambiguous and uncertain decision environment.

Marketing Manager

This school examines the acquisition process from an economic opportunity perspective as a supplier of goods and services, examining product and patronage attitudes, uses of information, and acquisition processes from the standpoint of providing satisfaction to needs and wants of individuals and organizations.

Policy-Maker

This school focuses on problems of the functioning of the acquisition process, areas of concern, deficiencies in operations, ways of dealing with change to more efficiently meet the organization needs and missions, of the goals of the larger environment, for social good, public good, and the national interest.

Within the approaches of these disciplines of thought are three main organizational perspectives brought in by operational settings: (1) the materials management perspective of practicing buyers in commercial organizations, (2) the organizational buying behavior perspective of practicing marketing managers, and (3) the acquisition management perspective developed by the Federal Government. Literature from all three operational perspectives is developed in this article.

The acquisition process is at largely the recipient end of "commercial exchange." In the exchange flow information, material, funds, technologies, commitments, services, plans, and a variety of other factors in both brief and durable relationships. It is a dyadic relationship, but also one shaped by many influences and forces. It is two sides of the same process--known by one as "acquisition management," and by the other as "industrial marketing management."

Acquisition Process from the Marketing School

A majority of the research on the acquisition process has been done within the marketing school, with the objective of understanding and satisfying the industrial customer. Both the acquisition process and the industrial marketing process involve the same seven elements. The "acquisition mix" involves (1):

- --Resource market analytical description and selection.
- --Resource institutional analysis and selection
- --Resource product/service decisions
- --Resource channel relationships
- --Resource valuation and price/cost decisions
- --Resource market communications processes
- --Resource market research and information systems.

Both marketing and acquisition organizations fulfill these same basic management functions: whether the acquisition organization is Acme Manufacturing or the Strategic Air Command. Acme obtains resources (materials, products, technologies, and so forth) from its resource environment, transforms them into products, and markets them to customer markets. SAC obtains resources from its environment (funding, major systems, technologies) packages them into operational capabilities, and markets them to DOD to achieve national security objectives. What is common? They both have critical resource market dependency in order to fulfill customer market expectations. Successful accomplishment of marketing objectives depends upon successful management of the acquisition mix.

A brief description will be given of each functional element.

Resource market description and selection decisions pertain to strategic/tactical study of the broad market base from which resources are obtained. Acquisition managers can exhibit resource market myopia by insufficient strategic definition of these markets. A firm does not acquire gasoline, but energy resources; aircraft, but transportation services; nuts and bolts, but fastening devices. What is the difference? It is the same critical difference which saw the demise of marketers who defined their products as "buggy whips" not transportation accessories; family boats, not leisure activities. Such narrow definition restricts the strategic perspective in ways which critically hinder decision-making. Acquisition managers need an augmented concept of resource markets to manage them and to understand competitive forces of supply and demand shaping them.

Resource institutional decisions pertain to sourcing within the resource market. A myoptic acquisition manager looks at Acme Manufacturing as a supplier of widgets. In so doing it misses Acme as a provider of technologies for widget production, of access to critical materials which go into widgets, of technological development programs for better performing widgets. Acquisition managers not only provide widgets to their organizations but also these broad resource factors which supplier/institutional definitions influence.

Resource product/service decisions involve a creative, entrepreneurial approach to "what is acquired." They call for effective and rigorous initiatives to influence the product/technological mixes of supplier institutions, at developing source capabilities, such as life cycle costing analysis, design to support, and technologies of the future. The acquisition manager is an expert product manager of the key supplier industries, influencing their decision processes, but without the need for formal R&D contracts.

Resource channel relationships is perhaps one of the most fundamental strategic issues of the seven. Acquisition is not an event, but a process. It evolves over time and is strengthened or weakened by decisions and actions. Source loyalty, mutual technology development, distribution of risk, are all key aspects of relationships. Effective acquisition management involves planning and implementing industry-base relationships over time, not "one-night-stands" as it were looking for products and program/systems on a situational basis.

Resource valuation and price/cost analysis includes the impact of long range effectiveness to the acquirer, strategic commitment and capabilities, and not merely the transaction price or even the landed or support price. It involves the valuation of all items of exchange, together with rigorous costing procedures, analysis of investment risk, and financial incentives for both short and long-term relationship goals.

Resource market/institutional communications look at all efforts to influence and stimulate action by marketing organizations. What proportion of corporate advertising is aimed at resource market impact and image, not merely sales market impact? Communications programs involve requests for proposal, effective specification writing, negotiation, and all communications both operational and strategic with resource market institutions and other members of the environment.

Finally, resource market research and information systems involve effective data collection for reduction of uncertainty in decision-making. Acquisition requires decisions on issues and the gaining of information both on an ad hoc and an on-going basis which influence all other aspects of the acquisition mix. Such information must be provided to the correct decision-making units, in a timely and efficient manner, free from bias.

Macro and Micro Modelling

The organizational buying behavior approach to the acquisition process--characteristic of the marketing school perceptual approach--has developed macro-models and micro-models of the buying process. As used within this school, the term "buying" behavior refers to all forms of acquisition, such as purchase, licensing, leasing, joint venture, and even to non-exchange oriented efforts to develop a more effective resource base outside of situational transactions. The next section examines both macro and micro modelling within the marketing school of analysis, but also integrates thought pieces from materials management and the Federal acquisition process where applicable.

Macro-Modelling

Macro models are of several types and are used in describing and analyzing sales markets for the

purpose of identifying opportunities for new product development and/or expansion of markets of present products. The most basic studies of acquisition institutions within a sales market setting are market classification studies using SIC data published by the government, although authors have contributed several other model types (2-3).Such studies describe organizational customers by geographic structure, organizational size, and industry data such as sales volume, market share, profitability, geographic scope, and competitive positioning. The focus of these models is not on process but on economic potential as an organizational customer.

A major aspect of macro-modelling is economic analysis of factors which influence the acquisition needs and perspectives of commercial and government institutions. In the light of economic forecasts, economic conditions, and interpretations of responses to these conditions, modelers predict opportunities for commercial initiatives with these organizations.Specific stydies examine market conditions, such as shortages, price changes, and trends (4-9) with the objective of presenting problems and opportunities in the marketplace based on customer expectations (9). Studies also focus on determining current actual "users" of products and services, potential users, conditions of use, and predictive demographics as a basis for sales forecasting.

One subset of macro-modelling, although closely related to micro-aspects of acquisitions, are studies on diffusions of innovations and new product adoption processes. This set of research examines in particular success issues (and failures) of new products among adopter and non-adopter institutions as a basis for better management of new product developments. The studies examine attitudes, influence processes within organizations, selection criteria, as well as specific situational and product attributes which tend to accompany success (11-18)

Also related to macro-models are studies on product life cycles. This concept argues that products and markets go through stages of inception, growth, maturity, and decline with characteristic acquisition strategies to which marketing programs must adapt. One set of research deals with the role of purchasing managers and its changes over product life cycles (19).

Micro-Modelling

This approach examines organizational and individual human processes which influence and determine the buying behavior in an organizational setting. The first set of analysis examines the internal organizational structure and perspective of the buying function (or more precisely, the buying decision unit) in both a formal and informal sense, including corporate and divisional/plant purchasing functions, the role and authority of influencers, acquisition rules, policies, and procedures, as well as specific situational strategies (20-32).

A second approach at conceptual modeling of the acquisition process examines segments of markets through a technique known as market segmentation (33-35). This approach examines customer benefits sought and attitudes toward benefit salience and potential/present suppliers' images along these benefits. Benefit segmentation recognizes three types of benefits to buyers: benefits during use (such as better reports of inventory quantities and less excess stock, reduced stock-outs), benefits from use (such as reduced investment in inventories) and benefits incidental to use (such as improved competitive appeal) in examining, say, a new information processing system for the purchasing function. Major research studies of organizational markets have grouped or clustered organizations with similar relative salience of benefits sought and/or perceptions of suppliers. An example of this is shown in Figure 1. and Figure 2.

Competitive Indicators	Major Competitors A	B	C	D
Market Position	-	++	+	-
Gen. Position Trend	+	+	++	-
Profitability	-	+	+	+
Financial Strength	-	+	++	+
Product Mix	+	++	-	-
Tech. Capability	++	+	+	-
Cost Outlook	+	++	-	+
Prod. Development	+	+	+	-

Figure 1: Competitive Analysis Segmentation

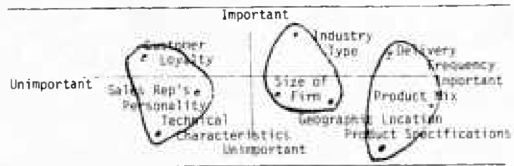


Figure 2: Segmentation Perceptual Mapping

In Figure 1, various competitive indicators are identified and competitors are classified in one of three ways according to perceived achievement of each of the indicators. Figure 2, on the other hand, clusters various selection attributes according to their relative salience to each other. That is, "industry type" is seen as more important than "size of firm", while "delivery frequency" is seen as the most important attribute of all, and "technical characteristics"is the least important. A two-dimensional scale is used for relative clustering of attributes. Within the set of relatively unimportant attributes, customer loyalty is seen as the most important item. Such perceptual clusters are developed using mathematical algorithms.

Figures 3 and 4 extend the perceptual mapping concept of market description. Studies such as these

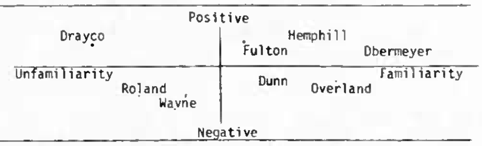
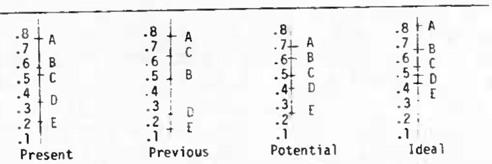


Figure 3: Competitive Perceptual Mapping



A:Experience, B: Price, C:Contract Fulfillment, D:Location, E:Size

Figure 4: Interval Attitudinal Scale of Vendors

when done by marketing managers, allow the supplier to see competitive positioning of various firms in the minds of purchasing personnel. In Figure 3, several firms are clustered in a perceptual map relative to overall positive/negative

image as a potential supplier as well as on the relative familiarity which the purchasing organization has with these suppliers. Similar cluster analysis can be done for any other two attributes (such as relative price ranges and product quality or innovativeness) or in multiple attribute space. When coupled with a map of the perceptual ideal, this allows potential competitors to reposition their marketing operations where gaps occur between what the ideal is and where current competitors are placed in perceptual space. Figure 4 develops an interval scale of competitors. Five attributes or benefits were selected for analysis--experience, price, contract fulfillment, location, and size. Respondents in buying organizations developed ranks on interval scales for three supplier categories--present, previous, and potential. These scales show not only the rank order of attribute preference, but the relative magnitudes of preference. They show a comparison with the ideal. A potential supplier can see where, in the view of customers, previous suppliers "went wrong" and where opportunities to approach the ideal are possible.

Another major set of micro-modelling involves sourcing and search behavior of customer organizations(36-39). Studies of information processing of acquisition decision-makers and attribute analysis during search have been done in various industries. Studies have shown areas of correlation between specific attributes and supplier positions on those attributes with relative selection for supply. One study showed service to be defined by customers more rigorously as:

> Helps in emergency situations, provides needed information, willing to cooperate in the face of unforeseen difficulties, offers frequent deliveries, helpful in overcoming occasional errors, supplies parts lists and manuals for service, makes available test and demonstration manuals and equipment, invoives correctly, helpful in providing special handling equipment, and provides information through promotional activities.

Some studies have shown correlation between relative attribute salience and the type of buying situation--new buy, modified rebuy, and straight rebuy--with a major indicator of attribute importance being the perceived transactional risk (technical and commercial).

Another important part of micro-modeling examines influences and the decision-base for acquisition decisions (40-42). Such studies focus upon changes in the organizational locus (formal and informal) of purchasing decisions, under what conditions purchasing should be centralized or decentralized, decision factors in delegation of purchasing authority in situational areas such as foreign subsidiary operations, and the internal role conflicts between various departments on purchasing decisions. These studies model the internal environment of the acquisition organization as a basis for planning sales communications strategies and contacts. Such "involvement-base" research efforts show internal organizational style and structure to be correlated with perceived risk due to two areas: perceived product complexity and perceived commercial uncertainty, among other factors.

Both macro and micro studies examine both the acquisition unit and a transactional dyad between both buyers and sellers; that is modeling of the internal acquisition organizational structure and process and the relationship situation between the organizations. One major study involves source relationships stability over time and relative opportunism vs. commitment as factors in acquisition strategy (43-49). Research has investigated several external and internal environmental factors associated with opportunism and loyalty. One of the factors of study is relative power and dependency in relationships, the exercise of power, and coping efforts to deal with dependency--technological, financial, and otherwise--on supplier organizations. Research examines conflict in the supply/distribution channel over a variety of technical and commercial issues, ways of reducing and handling conflict, and various strategic outcomes in policy and behavioral changes. The research in this area has focused in particular upon high technology organizations and the distribution of risk over the channel as an element of power and dependency.

A subelement of relationships modelling is reciprocity, including reciprocal factors in technology development, financing, materials supply, planning, and product development. An important aspect of functional reciprocity and prerogatives deals with organizational roles in such areas as product idea initiatives, pricing authority, cooperative financing, research and development, and cooperative advertising. Traditionally accepted roles, such as for new product idea formulation, have been challenged in support of the more "reliable" customer-active mode of idea generation, rather than a manufacturer directed product development approach. The customer active paradigm is more characteristic in the DOD acquisition environment than in most commercial relationships.

Finally, other areas of modelling in the interaction dyad deals with identification and management of opinion leaders, word-of-mouth communications in the adoption of industrial products and services, and studies focus on diffusions of new products within an industrial market and the role of key opinion leaders (and organizational leaders) in that adoption process.

Modelling the Acquisition Process

Models of the acquisition process which have been developed from the "acquirer's side" have taken several approaches--general models, new product models, and models of processes on an "after-the-fact" basis (for review and process improvement. Such models have been done of the general acquisition approaches taken by commercial and government organizations (50-51). Acquisition process reviews have been commissioned by major public agencies as a basis of public policy-setting. However, most studies have focused on specific products or on acquisitions of specific project situations. A major improvement in modelling has come after a recognition of several perceptual myths which had misguided model-building in the past. Among the various myths about buying/marketing which have been challenged are:

(1) Purchasing behavior is inherently economically rational.
(2) Technology sells itself in the marketplace
(3) The right kind of product sells itself
(4) Don't waste time on marketing when you haven't designed the product yet.
(5) The acquisition function comes largely from production or engineering personnel
(6) A low bid and price is the best way to select a supplier.
(7) Marketing is marketing, purchasing is purchasing regardless of the product or industry.

Various models which have emerged over the past fifteen years have evolved with varying degrees of complexity as these assumptions have been challenged. One major research stream came from Webster and Wind who examine the buyer's acquisition process for new products as well as the general applicability to the buying situation of the behavioral theory of the firm. Various research studies have developed a flow process to the acquisition function. This process follows:

Anticipation and recognition of need
Determination of specifications for problem solution
Detailed specification of needed item
Search for potential sources
Examination and evaluation of sources
Source selection and contracting
Establishment of an order routine
Evaluation of system performance

However, this approach has two major weaknesses: (1) it assumes a repeat buying situation, and, consequently, is weak conceptually in buying behavior for new products or less clearly defined acquisition processes, and (2) it deals with situational processes (a specific product) rather than managerial behavior in acquisition--which goes beyond a product acquisition setting toward long-term resource-base relationships. Several studies have focused on examining one aspect of acquisition, such as developing price competition or life cycle costing, while others have focused on varying model complexity with several factors assumed constant. Some models have had the purpose of identifying research directions (52-60). For an excellent review of the various models which have been developed, their relative weaknesses, and future research directions, see: Bonoma, T., G. Zaltman, and W. Johnston, Industrial Buying Behavior, (Cambridge, MA: Marketing Science Institute, 1977).

Some studies have focused on on the peculiarities of technological acquisitions. The objective has been to determine market evalation criteria for success as examined from a customer perspective. Major criteria for technology effectiveness in the commercial setting are: inventive merit, embodiment merit, operational merit, and market merit. Inventive merit pertains to a major, useful performance/cost/operation advantage which an invention provides, while embodiment merit looks at developing this into an actual physical product. Operational merit is the business impact upon a commercial customer, while market merit looks at the business potential and profitability to the marketer. Miniature transistor radios were a commercial success because they met all of these criteria. Inventive merit was found in the removal of size and weight which transistors (and chips) provided, less power drain and improved reliability. Embodiment merit was achieved through the development of pocket-sized radios, ferrite antennae, and improved tuning capacity. Operational merit came from removal of the need for franchised service dealers to support radio marketing and the ability to mass merchandise through chain stores, while market merit came from the ability to capture a new growth market which was mobile and oriented toward a "play as you go" ethic.

Both the Boeing 707 and the DC-8 aircraft were market successes because of the P&W J57 engine that provided fuel economy and speed advantages over piston aircraft. Embodiment merit came from the swept wing, larger aircraft capacity, with an improved range. Operational merit came with the simplified designs obtainable from both the B57 and KC135 military designs (extension of the market), while market merit came when airlines were able to develop the travel market because of increased speed, comfort in travel, and shorter flying times for long range distances.

What does all this mean? Commercial success of inventions and ideas are dependent upon the ability of the inventor to extend a business advantage to commercial customers through embodiment of operating advantages to improve market position or to extend the market. Commercial buyers assess new products on their operational and market merit and, consequently, these are important "product attributes" which must be designed into the product.

Finally, another stream of research examines competitive behavior of both marketer and buyer organizations. Just as marketers compete in a sales marketplace, so do buyers compete in an acquisition marketplace. Those who acquire the products and services of suppliers do so in competition with other customers even in broader industries. Competition for energy resources is broadly based and acquiring organizations must develop acquisition strategies not only within their own industries, but in competition with other industries.

A STRATEGIC PERCEPTUAL APPROACH

The introduction of this article noted the need for a strategic, entrepreneurial focus to the acquisition management function, and the potential for acquisition managers to make, key, strategic contributions to their organizations through such relationships with resource markets.The acquisition function has emerged from a role of placing orders and monitoring prices with as many suppliers as possible, whipsawing them, with emphasis on fast response, price, and quality to a managerial approach. Modeling efforts must reflect this basic change in scope and responsibility of the acquisition function. The managerial approach is presently emerging toward a planning approach, and one author noted that the acquisition function already has the following objectives: (62-69)

(1) Understanding material supply situations and markets and how they fit into organizational objectives and corporate strategies.

(2) Challenging specifications and using substitute materials.

(3) Developing long-range requirements forecasts.

(4) Assessing delivery and storage methods.

(5) Evaluating traditional sources and costs.

(6) Actively developing new sources.

(7) Using vendor allocation strategies.

(8) Auditing purchasing/acquisition performance.

Strategic acquisition management utilizes an augmented product concept, and a broad, non-myoptic concept of resource markets and acquisition competition for the supply from those markets. Such managers think in terms of an energy market, a materials market, an information market, instead of electricity, titanium, or computers. They think in terms of information processing technology, not semiconductors. They know as much about their resource markets, competitive efforts of various suppliers, as do the suppliers themselves. They adopt an important military principal: to know as much about your enemy as he knows about himself. They are excellent marketing managers in understanding their counterparts in supplier organizations.

What is being addressed here is a goal, an educational and performance standard for the acquisition function in the 1980s, especially within DOD agencies. There is an important need to understand the marketing (not merely economic) activities of defense industries and individual companies in those industries in order to develop effective, incentive-oriented relationships with them. Such managers examine strengths and weaknesses of supplier institutions within key trends in their markets, can do effective marketing audits of supplier institutions, and not just the pros and cons of a supplier for a particular buy.

They look at important issues such as investment for cost reduction and for technology development in both product and process technology. The see themselves in a key organizational role and responsibility to provide technology, both directly and indirectly, to their own organizations. They see their relationships with resource markets and institutions aimed at technological development within the resource industries as an important indirect asset of their own organizations.They become experts in technology transfer, and not merely product buying. They manage the development and transfer of such technology entrepreneurially.

Formulating a Strategic Acquisition Profile

Responses to an acquisition strategy orientation include both organizational change, process change, and relationships change. Organizational change responses include changes in the organizational context of the acquisition function, such as movement of the function from a subordinate position to a corporate vice-presidential or directorship level, including membership on the executive committee and key decision-making bodies. It includes coordination, if not functional involvement in the acquisition implications of important corporate strategy decisions--such as markets, products, diversification, or geographical expansion. From this comes the need to forecast the necessary resource development plans to meet the strategic plans of the corporation.

Process responses include such areas as strategic acquisition planning, rather than situational responses, including important management steps such as: strategic issue identification, issue response planning, organization and development of response programs, information systems to monitor strategic trends, and evaluation systems of strategic actions and programs. Yet even with this approach an organization can be reactive, rather than proactive. It may not necessarily anticipate crises, formulate strategies in advance, and plan responses. Strategic acquisition management necessitates the formulation of long-range objectives by resource category and industry, policies and procedures for achieving necessary resource sufficiency, and aggressive, affirmative programs aimed at gaining strategic compromise among resource environment institutions--based on both macro-analysis of environmental markets and micro-analysis of supply institutions.

One important process tool is the resource market audit, where a systematic evaluation is made of all functions within the acquisition mix mentioned earlier. This audit is part of the formal acquisition master plan which is developed and then analyzed by senior corporate personnel. Many organizations consider acquisition master plans to contain:

> Technical product/performance requirements and assessmant of mission capabilities needs.

Such a narrow statement is similar to naive marketing plans in industrial companies which are developed by engineers and technical personnel. They miss the operational and market merit aspects of the innovative assessment process and, consequently can lead to failure. Acquisition master plans are resource market based and have a major foundation in entrepreneurial understanding of the commercial motives and capabilities which are present and which are emerging within institutions. Matching and exploration of these against the needs of the acquiring institution is only one part of the plan. Such plans identify problems and opportunities, the makeup and rationale behind commercial strategies of supplier organizations, not just materials management skills to serve the production/logistics needs of the company. They contain technological forecasts with implications for business conditions as well in both resource and user end markets. Strategic acquisition managers know what tough strategic questions to ask, and where to get answers.

Results of the Process

Results include not only the internal document known as an acquisition master plan, but also relatioeships plans and programs. It is not within the scope/length of this article do dwell in-depth on how to approach a strategic acquisition

management operation. Other sources are available to explain that. However, it is the purpose to provide a conceptual understanding of this approach to the acquisition function. An acquisition master plan is built first upon corporate mission objectives. Such a plan might have the following breakdown as an example:

Acquisition Master Plan

Energy Resources

Forecasted usage through AD 1990

Forecasted world supply through AD 1990

Geographic distribution of supplies and key economic/political changes...

...

Competitive strategies of suppliers...

Development activities for supplies

Price policies

Contract supply, spot market, reciprocal technology developments...

...

Forecasted competitive uses...

Growth statistics of usage industries

Heavy equipment manufacturing industry

Planned plant expansions

Energy conversion plans

...

A second, more micro-oriented output from strategic acquisition management is a source relationships plan. Many acquisitions are made on a situational basis. The organization needs a product, service or stream of supplies. It selects a supplier, a contract or supply agreement is drawn up, and, if everything goes well, the agreement continues until the need is terminated. The relationship is quite superficial, is directed only toward the specific product need, and does not get into issues beyond this focus. The organizations usually stay at "arms length" in many areas of decision-making.

Source relationship plans have two purposes: First, they operate under the assumption of an acquisition resource market, rather than a set of suppliers, and the notion that there is a relationship with that market over time, not just to satisfy a specific, situational product need. Second, they assume that the context of the exchange interaction is open to mutual, negotiable initiative which can go beyond the situational perspective and which can involve joint, mutually dependent, effort in a broad range of areas such as technology, financing, and management planning. It establishes an external partnership between the acquiring organization and the resource market, with emphasis upon specific institutions in the market and their role in the resource needs of the acquirer over time.

Source relationship plans are broad, guiding documents against which specific sourcing initiatives are made. They are long-range in scope and deal with developmental aspects of the role of specific supplier institutions and mixes of institutions. An important aspect of this approach is a strategic resource mix portfolio plan. Acquiring organizations obtain both products and relationship services from their markets. A source mix is made up of a mix of institutions, which is dynamic over time, which provides broadly for meeting a complex group of needs. For example, a specific institution may be included because of its geographical scope of operations or technological innovativeness, while another institution is included as a price competitor, another as a financially strong source with several product lines available, and still another for growth potential in new product lines. Such a portfolio necessitates a broadly based resource market conceptualization of needs over time and priorities of these needs. It then seeks to develop a present and emerging cadre of institutions and institutional relationships to provide for the dynamics of satisfying these needs.

An example of a management system which may emerge in this direction is in the avionics industry relationship of the DOD agencies. An avionics master plan includes technological forecasting of, say, needed avionics technology to meet mission requirements. It may then develop specific acquisition strategies for developing these technologies within the industry-base, for sharing risks, financing development, and production and delivery forecasts, as well as relationship options ranging from internal investment by supplier institutions, to joint ventures, to incentive contracting.

Formal source relationships plans are developed by acquisition managers from complex inputs received from the supply environment, from internal need forecasts of the acquisition organization, and from strategic planning sessions of the corporate executive officers. They are coordinated with selected documents of the organization, such as long-range marketing plans. They include important inputs in the area of life cycle cost analysis, field support requirements, and changes in operational capabilities to meet the organization's growth and development plans. Specific market objectives and strategies provide a good basis for determining strategic resource needs.

Areas of strategic deficiency within the resource market are addressed with programs, such as needed changes in industry structure, level of acquisition (vertical channel), and application of social/economic programs where applicable. DOD research programs, for example, have uncovered such problems in resource markets: the impact of cyclical contracting practices on the industry-base structure, problems in surge capacity, inadequate investment for technological modernization and cost reduction, trends toward contractor diversification away from government products, fewer subcontractors, and increased dependency on foreign military sales. Resource market plans examine the specific problems in areas such as these in specific markets and develop ways to work through these problems--in cooperation with the institutions in the markets--to achieve the imp-

portant long term needs of the buyer organization.

Basic questions which are useful in beginning strategic acquisition plans include:

(1) Broadly speaking, what resource markets are we in? What is the competitive business profile of this market and the key firms in it? What are the implications?

(2) Could I write a good marketing plan for a key supplier in that market--do I understand the market and business operations well enough for this?

(3) What are our needs and expectations of these markets over the next five-ten years? How well will they be met and upon what is successful accomplishment dependent?

(4) How are developmental strategies progressing (a) within each market, and (b) as a result of relationships with specific institutions, with specific issues and initiatives?

(5) What are the performance expectations of institutions in these markets and how will we measure them? How do they measure them-- return on investment, market share changes, diversification objective accomplishment? What conflicts occur in their strategic operations and our strategic needs? How can they be resolved? What are the issues?

(6) What are key economic, political, and social trends shaping the market?

An important aspect of acquisition plans is management involvement in technological decisions. However, many managers still do not involve themselves (for a variety of reasons) in such decisions. They are the prerogative of technical personnel. Often technological decisions are evaluated from technical performance criteria, not operational benefit characteristics or long term impact on resource relations. With the benefits view of technology evaluation a manager focuses on evaluation of such issues as the relative time of two different refrigerators to make ice cubes, not their relative "pull down capacities," or the maintenance free expectations of a machine, not its pump seal characteristics.

In making strategic technological evaluations it is important to examine five areas: (1) inputs needed for the technology, (2) capacity of the technology (output), (3) performance aspects of technology--such as in improving efficiency, (4) flexibility of the technology to respond to varied needs, and (5) environmental effects of the technology. Economics of technologies must examine both performance in the short run and the capital intensive decisions to improve production efficiency such as spending more on capital investment to reduce maintenance costs. Such decisions are made best by managers, not technicians.

General Acquisition Planning Information

In review, strategic information for acquisition planning encompasses five major areas:

1. Acquisition Plan Content and Purpose

   Broadly speaking, an annual acquisition plan is a document which sets forth business goals with respect to internal operations and with respect to resource markets in acquiring products, services and technologies to reach organizational goals, and (b) action programs required to achieve these goals within the twelve month time frame, but with a long-term perspective.

   An acquisition management plan is organized, documented, and written to communicate:

   a) Definition of resource acquisition needs--past,present, and future.
   b) Definition of opportunities and problems facing the organization in meeting acquisition needs.
   c) Establishment of specific realistic objectives concerning resource acquisitions.
   d) Definition of acquisition programs and actions to achieve these objectives.
   e) Pinpointing of responsibility for program planning and execution.
   f) Establishment of timetables and controls.
   g) Translation of objectives and programs into budgets, personnel, organizational structure changes through coordination of various departments.

2. Checklist in Acquisition Plan Development

   An acquisition plan should include:

   --Situational issue analysis to develop an effective resource market management scenario.

   --Formulation of objectives

   --Development of action strategies involving resource market relationships

   --Action statements and assignments

   --Management endorsement, support, and control mechanisms

3. How Acquisition Planning Fails.

   --Lack of real, formalized plans

   --Lack of adequate situational analysis in terms of opportunities, problems, and long range dynamics of resource markets

   --Preparation without adequate participation

   --Unrealistic goals

   --Inadequate selling of plan during and after preparation

   --Unanticipated competitive moves in the market, or deficiencies in plan execution.

4. Reasons Why Resource Market Information is Needed.

   -As a basis for planning on facts, not assumptions.

-To identify problems and opportunities for the setting of management objectives

-To guide the planning of other organizational functions.

5. What Facts are Needed?

-Who are market suppliers, users of the product, service, technology? Where are they located and how much do they sell or buy within their industries? When?

-What efforts to develop supplier interest in the buying organization have occured? How successful?

-What are the price-making forces in the environment?

-What competitive channels of supply are open and what are the functional strengths and weaknesses of them?

-What marketing methods are used by competitors and how do we deal with them?

-What overall objectives do suppliers have with respect to our sales market and us as customers?

-What is the relationship of the product under immediate consideration to other products sold by suppliers?

From these questions, answers are developed in eight sections of the acquisition plan:

-Resource market relationships plan

-Product/service development plan

-Technology development plan (product and process)

-Resource-base development plan

-Price/cost analysis plan

-Logistical development plan

-Financial management plan

-Manufacturing analysis plan

Conclusion

Persons interested in a broader, more detailed conceptual example of modelling issues presented in this paper are invited to consult references and to get further reference material from the author.

Many managers resist strategic planning--it provides a straitjacket for decisions. They get too busy fighting fires to think that far ahead. They lack the business strategy conceptual skills and analytical skills to develop such a plan. The list goes on and on. The result--situational catastrophy and crisis management--weaknesses over time in resource markets and relationships. Decreases in organizational effectiveness.

As the acquisition function emerges from the "womb of manufacturing" to become a key corporate level function in organizations, it is involved in development of its managerial skills Conceptual models must address these changes. Several schools of thought have approached various descriptive/analytical/predictive approaches to acquisition management with various degrees of explanatory and management usefulness. DOD agencies as well as commercial organizations face the following needs in the 1980s as a result of this emerging trend in acquisition management:

--Improved conceptual/strategy skills and capabilities of acquisition managers, including better capabilities at industrial marketing analysis and other conceptual tools to view their resource markets.

--Improved educational opportunities for mid-career and high level managers who will fill top acquisition management functions.

--Research aimed at determining the level and content of effective an ineffective management actions of the acquisition function, specific needs for improvement, and a better understanding of resource markets as industries.

--Increased research at modeling strategic aspects of the acquisition function and formulation of research hypotheses.

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COST ESTIMATING

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An Engineer's View of Parametric Cost Estimation

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ABSTRACT

Over the last two decades cost estimating has begun to emerge from the "black art" stage. A newcomer to the area of parametric cost estimation presents a perspective on how far parametric models have progressed in aircraft performance analysis. Models applied to cost are then the normal extension. As experience has shown in the foundry metals industry, cost can be driven by the weight of the product.

The present day parametric models for cost estimation are a function extension. There is still work to be done, however. More analysis must be made of the direct and indirect functional relationships and statistical relationships must be further studied to surface weaknesses in the cost estimator elements.

Parametric modeling of costs appears to be a quantification technique with enormous potential. In this paper an engineer tries to provide a view of that potential as he perceives it.

THE BASIC RELATIONSHIP

The merge of interests between the engineer and the "bean-counter" is a most unusual one. The engineering disciplines in all their technical jargon of brake horsepower, entropy, coefficients of pressure and friction, etc. have traditionally looked upon the accounting function as just another stonewall raised by the "Jewish Engineers" in the Business College.

In the last two decades, however, the two disciplines have found an area of common concern: Parametric Cost Estimating. Now, parametric estimation has been used for many years in many product performance estimation analyses. The best and most familiar example is that of aircraft performance, about which more is presented below. However, other examples are steam tables in steam boiler performance analyses, and, one that is used but to a lesser extent these days, foundry castings cost estimation. Illustrations of the latter are sewer pipe, manhole covers and the stem pipe sections that attach the cover to the pipe sections in sewer construction. Each of these is a simple casting and cost by the pound is a common means to selling these items. In more complicated castings, per pound cost is only a part of the cost formula. Additional factors in the formula include the cavity encompassed by the metal, the type and amount of alloying elements, the molding and other skills required, and the number of sand cores, chills or other items necessary to produce a quality metal casting. These become part of the additions to the parametric model or formula necessary to completely estimate the cost.

Therefore, one can appreciate the mutual interest focus of the engineers and the accountants in these days of increasing emphasis on cost reduction and accurate estimates.

Theory of Parametrics

Most people can appreciate that fresh produce, meats, fish and certain other commodities can be sold on a cost per unit weight basis. To carry that same appreciation on to the purchase of a major modern-day weapon system including all its sophisticated electronics, high technology metallurgy, and lengthy engineering effort is to ask quite a lot without a good deal of preparation.

To try and bridge this gap, consider the two equations which form the foundation for the entire performance envelope spectrum of an aircraft:

$$\text{LIFT} = L = \tfrac{1}{2} \rho S V^2 C_L$$

$$\text{DRAG} = D = \tfrac{1}{2} \rho S V^2 C_D$$

Where ρ = an ambient air constant

S = the area of the wing

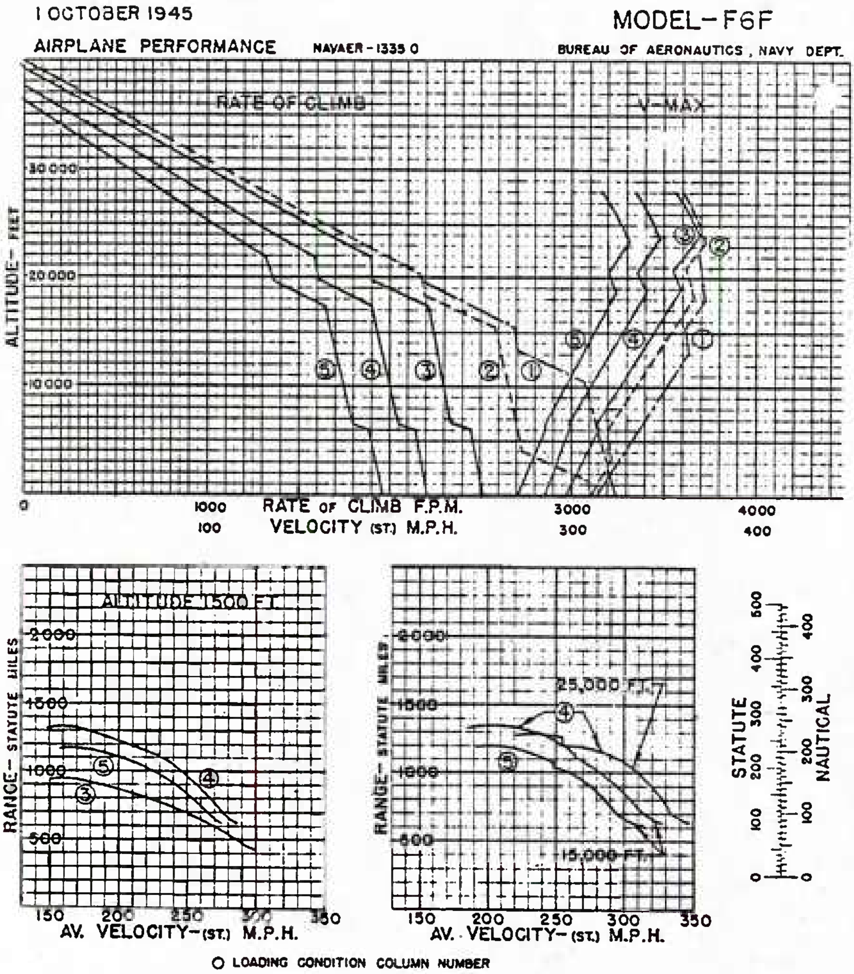
V = the velocity of the aircraft relative to the local air mass.

C_L and C_D = the respective coefficients of lift and drag corresponding to a particular NASA airfoil cross-section and a series of drag of air friction components.

Using these two equations, which have long been known, and by making various assumptions as to aircraft attitude, altitude, power availability, controls attitudes, etc. an entire set of charts is developed. For example the U.S. Navy's performance manual for the F6F, Hellcat, was 6-8 pages including only one page of charts in 1944.

(See Fig. 1.). The same manual provided our USAF 1980 pilots for the F-16 fighter built by General Dynamics has over 70 pages of specific charts to assist in planning every mission. The more complete performance charts in the G.D. Flight Test and design offices fill several thick notebook sized volumes.

One example of such a more modern chart is shown in Figure 2. Shown are the families of curves for the parameters necessary to determine the expected (estimated) ground run on take-off for a B-66 model aircraft. Beginning at the left center of the chart one enters the calculations with the known outside air temperature. Each airport is at a known elevation above sea level and the intersection of the airport elevation and the temperature parameters (the chart at the upper left) is the first turning or check-point in Figure 1. Progressing to the right, the pilot knows the expected weight of his aircraft at take-off and finds the intersection of the left hand chart extension with his aircraft weight. Dropping down to the known runway slope and any cross or head winds the meterology office tells him about, the expected ground run in thousands of feet is read off the chart at the lower right. (See Fig. 2.).



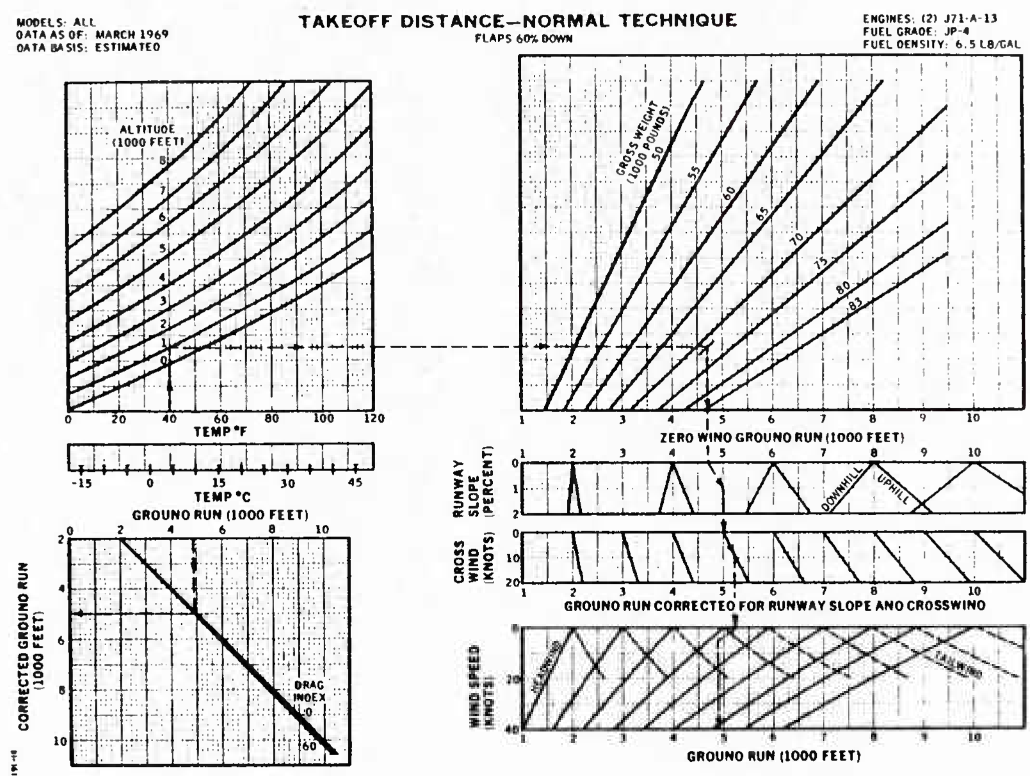
The data for these charts are gleaned from calculations, wind tunnel tests and actual flight testing of the aircraft before the aircraft is made available to the military or civilian pilot. Thus reams of data, often statistically analyzed, become the basis for the resulting charts.

This is the exact same method for cost analysis estimates under parametric model techniques. Cost accounting data on material and labor costs are easy to understand -- though often very dicy to gather and categorize for proper analysis. A more difficult area is the relating of engineering drawing number and size to costs. However, experience has shown that the 'A' size engineering drawing, i.e. the largest ones and those focused on assembly of or accumulated smaller detail parts, correlate directly with engineering and development costs for both electronic and structure elements. The weight, complexity of the item relative to the state-of-the-art and the complexity relative to the particular company's capabilities are families of data which cascade to provide a cost estimate.

THE PROBLEM

Lack of Standards. There is a great deal of controversy about this area of cost estimating, however. Strong disagreements exist concerning the higher order or multiple effects of technical complexities in a product, the effect of the so-called Learning Curve or Boeing Curve, or the treatment of inflation predictions. The multiple judgments by the various authors of the parametric models being marketed. There are several more corporate proprietary models that apparently do not show sufficient agreement in cost structure yet to justify acceptance of a common mathematical logic.

There are also a number of Department of Defense models about which very little has been published in so far as technical detail is concerned. The Office of the Secretary of Defense, P.A.&E. uses two or three models to estimate costs on overall weapons systems and there are two to three more in each of the services: the Navy has one at



NAVSEA for ship construction, the Army uses one in their life cycle cost analyses, and there are a number of others. Most of these focus on relatively narrow areas and do not perceive larger overall cost areas. Thus little standardization of data manipulation has developed yet.

Based on the wide spectrum of applications possible for these models, some organized set of procedures and standards should be made available. The International Society of Parametric Analysts is the presently available societal reference point and is attempting to pull together all these organizational and technical aspects.

Technical Problems. There are additional areas of the cost estimation analysis that require study, however, that are far more technical in nature.

One area of technical analysis need is the measure of effect on manufacturing complexities for the company with increasing numbers of numerically controlled machine tools and CAD/CAM equipment. A number of companies have reached far into this area while others are not moving as fast. What effect does this relative difference have on the scaling factor for the complexity parameters?

A second technical area is the inclusion of the multi-product line effects on the cost and schedule estimates. It is normally assumed that a single product allows focused concentration where a product mix causes thought process as well as manufacturing delays relative to the single product. The relationship and relative impact of direct and indirect labor including the relative organizational differences impact are also a part of this technical analysis need.

In present parametric models, the approach appears to be that each parameter used is qualitatively considered equal to all others in a given category. Yet cost accounting statistics have already had some judgment factored in and the additional deductions necessary to relate parameters may induce "error" into the calculations. Thus comparison statistics may well be available or collectable to better "fit" the quality levels of the data base parameters to an accumulated estimate where the weaknesses are known and not glossed over. In this manner known statistical techniques for error or risk analysis can then be applied.

Finally, parametric cost modeling does not have a means yet of measuring the influence of management expertise or training on the cost estimate. With the enormous amount of effort being spent on management conferences, in-house training and measurement of effectiveness by just about every corporation in the Fortune 500, there must be a way to gain some insight, if not an accurate measure, of the effect on cost/schedule of a change in maangement expertise of emphasis.

These specific examples provide a view of the problem spectrum waiting to be analyzed by the cost accountant and engineer group. There are areas requiring inductive as well as deductive reasoning in the type of model and the combination of skills appears to be solving the problems -- albeit slower than managers would like to see them solved.

CONCLUSION

There is a large area of need in the merging of expertise of the Accountant, Cost Accountant and Engineering skills where project cost estimation is the focus. Parametric models appear to be one answer to better cost and schedule analyses. There are several fine models presently available considering the recent emphasis placed on them. The International Society of Parametric analysts is one general effort formed to further this management tool. A lot of work still needs to be done in firming up the present known concepts and setting usable standards. In addition, there are several areas of further research work that will make parametric models a key decision-makers tool.

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A COST FUNCTION FOR MILITARY AIRFRAMES

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ABSTRACT

Recent theoretical and empirical work in the areas of learning curves, production rate and cost estimation of airframes has seemed to yield contradictory conclusions.

This paper synthesizes this work. The synthesis yields a model of the acquisition process that captures the interaction between learning and both endogenous and exogenous production rate changes.

This is accomplished by modifying a previous model to include previous production experience and yearly production targets. This permits a production program to be modeled as a series of discrete tasks connected by experience. By this device the impact of an exogenous increase or decrease in deliveries can be modeled. Likewise, the impact of stretching a lot out over a longer period of time can be modeled by this procedure.

The model is also expanded to include the impact of several restrictions on production. Finally, plans for estimating the cost function and illustrating its use in program management are discussed.

INTRODUCTION

Due to cost overruns, Congressional concern, and a continuing need for better planning estimates, it is imperative that new techniques be developed and old techniques refined to obtain better cost estimates for major weapon system production and acquisition. Along with these techniques, a better understanding of the factors and forces that determine cost is required. In particular, the sensitivity of program costs to alternative policy decisions must be accurately estimated if we are to meet the challenge of providing wise acquisition policy. Furthermore, the cost impacts of policy decisions must be readily available if they are to have an impact in the dynamic world of systems acquisition.

This research is concerned with estimating the cost impacts of policies that affect the production rate during a program. For convenience we discuss these effects at two stages in the life of the program.

At the outset of a production program, a tentative monthly production schedule for the program is negotiated between the contracting parties. This schedule permits planning for work force buildup, facility and tooling needs, and the ordering of long lead time items. This early situation is referred to as the planning stage.

Although the planned delivery schedule covers the life of the program, formal contractual agreements between the Department of Defense and manufacturers usually cover only one year's delivery requirements. Delivery requirements for subsequent years are funded through the exercise of options or separate contracts as funds are appropriated by the Congress. Over time the situation tends to change. Funding in a particular year may be insufficient to cover the planned production. Or a national emergency or changed mission requirements may argue for changes in production rate. This later situation is referred to as the production stage.

Intuition, economic theory, and recently, empirical studies argue that production rate changes, at either stage in the program, affect program costs. In addition, Gaunt [7] points out that cost penalties for production rate changes are now embodied in some contracts.

The foregoing is generally accepted, but there is substantial disagreement about both the magnitude and the direction of the impact of production rate changes on program costs. Empirical studies of airframe programs in the last five years have documented cases where increases in production rate have been associated with increases, decreases, and no change in the unit cost of production.

BACKGROUND

The theoretical foundations for production rate impacts on costs are as old as the study of economics. Adam Smith's pin factory example [18] is an early statement of the effect. More recently, Asher [3] recognized the potential importance of production rate to aircraft production costs; but he could find little statistical support for

the idea. Since 1956 the idea of combining learning effects and production rate effects in the explanation of aircraft costs has proceeded along two rather separate routes.

In 1959 Alchian [1] provided some theoretical observations concerning the interaction of learning and production rate. His paper was followed by Hirshleifer's 1962 discussion [8]. Preston and Keachie [16], Oi [14] and Rosen [17] also made contributions. All these papers added to the understanding of the process by which learning interacted with production rate to affect cost; but they were conceptual and almost completely data free. Furthermore, for the most part, they generated results that were far too general for statistical estimation.

The second line of development has been mainly empirical. Ever since Alchian's 1959 paper [1], Rand Reports [9, 10, 11, 12] on aircraft cost estimation have attempted to include both volume and production rate as independent variables in their cost estimating relations. In his 1963 paper Alchian [2] reports this attempt as early as 1948. Even though Alchian argues that both variables should be important, the resulting empirical work credits production rate with little, if any explanatory ability. In fact, a recent study [10] states:

> In general, however, we must conclude that for predicting the overall effect of production rate on aircraft cost, generalized estimating equations based on statistical analyses of our sample of military aircraft would be too unreliable to be useful.

The Rand studies have been cross-sectional studies characterized by a few observations on many aircraft programs. More recent work by Womer [25], Smith [20] and his students, Congleton and Kinton [5, 19] has reached the opposite conclusion. The studies under Smith's direction have been time series studies on single airframe programs. Unfortunately, these studies have been almost devoid of economic theory. As a result even though some of the studies indicate that production rate is correlated with costs on a program, our understanding of the process by which this happens is fuzzy at best. Without this knowledge the results cannot be intelligently used for policy guidance.

Recent work has been closing the gap between these two lines of research. Washburn [21] and Womer [23] derive cost relations consistent with economic theory in forms suitalbe for empirical estimation. This work shows that, in the absence of outside forces, the producer attempting to minimize cost will change the production rate over time. That is, some of the production rate changes in weapon systems' programs do not result from government action. Womer [22] points out that these results refute some previous theoretical work. They also provide a potential explanation for Smith's seemingly contradictory results.

At the same time, the unique data problems of combining variables measured by time periods with others measured by units produced have been examined by Womer [24]. Finally, preliminary work [6, 13] has started on relating Womer's [23] model to the Rand data.

This paper reports on the first stage of a research effort designed to synthesize the existing theoretical and empirical work that relates production rate and learning curves.

Here Womer's model [23] is modified to include resources that cannot be varied during the production program. This permits a more realistic distinction to be drawn between the planning situation before the program begins and the more restricted production situation.

Next the model is applied to the problem of producing to a delivery schedule. This results in the production program being modeled as a series of discrete tasks connected by experience. By this device the impact of an exogenous increase or decrease in deliveries can be modeled. Likewise, the impact of stretching a lot out over a longer period of time can be modeled by this procedure.

Finally, the impact of policy on the model is illustrated by considering the problem subject to a constant workforce constraint.

THE MODEL

The model uses a production function to relate output rate to two classes of inputs. The relative prices of resources within each class are assumed to change. Thus, each class may be represented as a single composite resource. One class is composed of resources whose use rate cannot change during the program. The resources of the other class can be used at changing rates throughout the production program. This simple classification of resources is just the usual distinction between resources which gives rise to fixed and variable costs. The variables of the model are described below:

$q(t)$ = output rate on the program at t
k = quantity of fixed resources
$x(t)$ = rate of variable resource use at t
$Q(t) = \int_0^t q(\tau)d\tau$ = cumulative production experience at t.
δ = a parameter describing learning
γ = a returns to scale parameter
C = discounted program cost
T = time horizon for the production program
ρ = discount rate
V = volume of output to be produced by T
P_k = price (in units of the variable resource) of the fixed resource.

The production function relates the quantity of fixed resources, k, the rate of variable resource use, x(t), and cumulative production experience, Q(t), to the output rate, q(t). The production function is assumed to be of the form

$$q(t) = k^{\alpha} x^{1/\gamma}(t) Q^{\delta}(t) \qquad (1)$$

This functional form embodies two summary characteristics of the production process:
(a) the production function is homogeneous of degree $1/\gamma$ in the variable resources;
(b) neutral technological change is induced in the production process as a log-linear function of cumulative production experience.

The homogeneity assumption is frequently made in empirical studies of production. Here we also assume that $\gamma > 1$ implying decreasing returns to scale. Otherwise, an optimal production program would crowd all production into an arbitrarily short period at the end of the program. This assumption also implies that production rate has no absolute maximum. However, for high values of γ, the resource penalties associated with increasing q(t) may be prohibitive.

The assumption, that production experience induces neutral technological change in the production process, simplifies the analysis considerably. Otherwise, both the impact of experience on the use of each resource and the relative impact of each resource on output rate must be specified.

The resource prices and the discount rate are assumed to be exogeneous constants. Thus discounted program costs in units of the variable resources are:

$$C = \int_0^T x(t)e^{-\rho t}dt + P_k k \qquad (2)$$

So far the model is not much different from the model of [23]. Here, however, we assume that the firm must meet an imposed delivery schedule. That is cumulative production levels, Q_i, at particular points in time, t_i, are specified in the contract.

The firm is assumed to minimize the discounted program costs incurred to meet the delivery schedule. The firm's problem is characterized as:

$$\text{Min } C = \int_0^T x(t)e^{-\rho t}dt + P_k k \qquad (3)$$

subject to $q(t) = k^{\alpha} x^{1/\gamma}(t) Q^{\delta}(t)$

$x(t) \geq 0 \qquad Q(t_i) = Q_i \qquad Q(T) = V$

$k \geq 0 \qquad Q(0) = 0$

All of the interesting results of using this model can be demonstrated with a two point production schedule, i.e. t_1 and T; so i is set equal to 1 below.

The solution to this problem is presented for both the production situation and the planning situation.

THE PRODUCTION SITUATION

In the production situation the delivery schedule and k are fixed. The solution to the optimal control problem at (3) requires that the optimal time path of x(t) be found over the range $(0, t_1)$ and the range (t_1, T). With a little work the optimal time path is found to be

$$x(t) = [\rho/k^{\alpha}(1-\delta)(r-1)]^{\gamma} Q_1^{\gamma(1-\delta)} [e^{\rho t_1/(\gamma-1)} - 1]^{-\gamma} e^{\rho\gamma t/(\gamma-1)}$$

when $0 < t < t_1$

and

$$x(t) = [\rho/k^{\alpha}(1-\delta)(\gamma-1)]^{\gamma} (V^{1-\delta} - Q_1^{1-\delta})^{\gamma} [e^{\rho T/(\gamma-1)} - e^{\rho t_1/(\gamma-1)}]^{-\gamma} e^{\rho t/(\gamma-1)} \qquad (4)$$

when $t_1 < t < T$

Cumulative discounted costs at any point in time are found by substituting (4) into the objective function at (3) and changing the limit of integration from T to t.

This yields

$$C(t) = Ak^{-\alpha\gamma} Q_1^{\gamma(1-\delta)} [e^{\rho t_1/(\gamma-1)} - 1]^{-\gamma} [e^{\rho t/(\gamma-1)} - 1] + P_k k$$

when $0 < t < t_1$

and

$$C(t) = Ak^{-\alpha\gamma} Q_1^{\gamma(1-\delta)} [e^{\rho t_1/(\gamma-1)} - 1]^{1-\gamma} + Ak^{-\alpha\gamma} (V^{1-\delta} - Q_1^{1-\delta})^{\gamma} [e^{\rho T/(\gamma-1)} - e^{\rho t_1/(\gamma-1)}]^{-\gamma} [e^{\rho t/(\gamma-1)} - e^{\rho t_1/(\gamma-1)}] + P_k k \qquad (5)$$

when $t_1 < t < T$, where $A = [\rho/(\gamma-1)]^{\gamma-1}(1-\delta)^{-\gamma}$

Figure 1 illustrates the cumulative costs for three different delivery schedules producing 240 aircraft in 40 months.

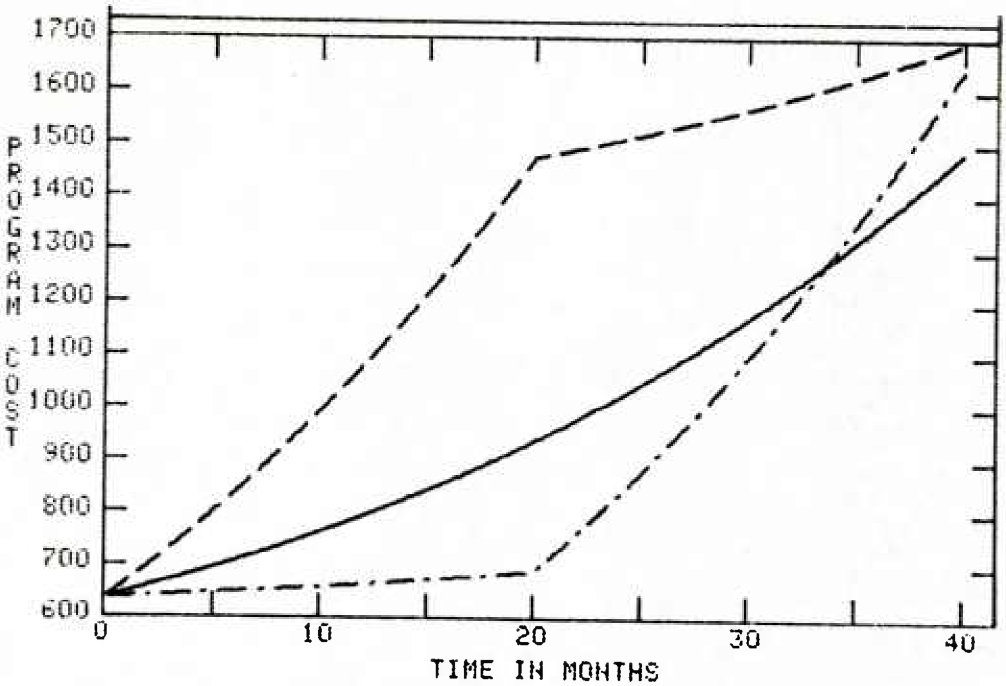

Figure 1. Cumulative Program Cost as a Function of Time

In Figure 1 and, except as noted, in the following figures the parameters of the model take the following values:

δ = 0.4	V = 240
γ = 2.0	Q_1 = 10 or 100
T = 40	P_k = 1.0
ρ = .03	α = .3

One schedule, resulting in the solid curve, does not require any particular level of output by month 20. (This is found by substituting V and T for Q_1 and t_1 in the first segment of (5).) The dashed curve requires 100 aircraft by month 20, while the dash-dot curve requires 10 aircraft by month 20. It seems clear that the least expensive way to acquire 240 aircraft in 40 months is to impose no additional restrictions on the delivery schedule. This will also be the case if

$$Q_1 = V[(e^{\rho t_1/(\gamma-1)}-1)/(e^{\rho T/(\gamma-1)}-1]^{1/(1-\delta)} \quad (6)$$

THE PLANNING SITUATION

In the planning situation k can be chosen in an optimal way. From (4) and (3), total program costs for any level of k are found as:

$$C = k^{-\alpha\gamma} A Q_1^{(1-\delta)\gamma} [e^{\rho t_1/(\gamma-1)} - 1]^{1-\gamma}$$

$$+ k^{-\alpha\gamma} A (V^{1-\delta} - Q_1^{1-\delta})^{\gamma} [e^{\rho T/(\gamma-1)} - e^{\rho t_1/(\gamma-1)}]^{1-\gamma}$$

$$+ P_k k \quad (7)$$

$$c = k^{-\alpha\gamma} f(Q_1, t_1, V, T) + P_k k$$

The optimal value of k can be found by:

$$\frac{\partial c}{\partial k} = -\alpha\gamma k^{-\alpha\gamma-1} f(Q_1, t_1, V, T) + P_k = 0$$

$$k^{-\alpha\gamma-1} = P_k / \alpha\gamma f(Q_1, t_1, V, T)$$

$$k = \{\alpha\gamma [f(Q_1, t_1, V, T)]/P_k\}^{1/(\alpha\gamma+1)} \quad (8)$$

Figure 2 illustrates C as a function of k for the three delivery schedules used previously. Figure 2 reveals two interesting facts. First, there is a unique value of k that is best for each delivery schedule. Second, the ability to choose k does not totally remove the cost penalties for imposing delivery schedules.

This planning cost function can be used to determine the appropriate delivery schedule. For example, suppose t_1, V, and T are known, Figure 3 shows C as a function of Q_1. Using this information, together with information on the benefits of having more or fewer aircraft available at t_1, the appropriate value of Q_1 can be chosen.

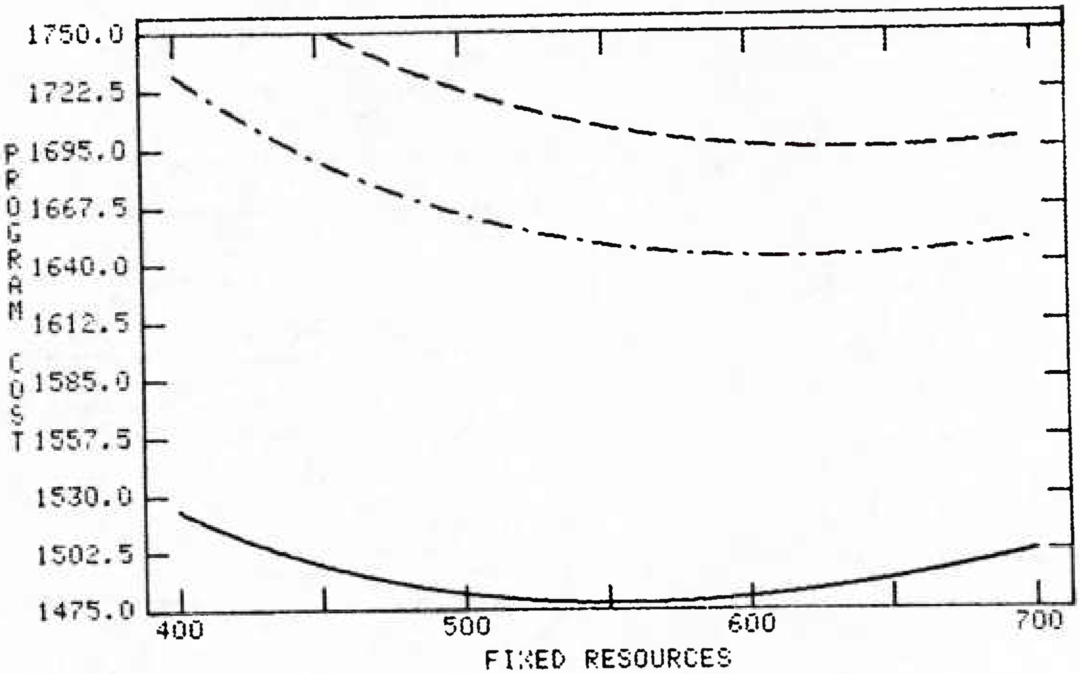

Figure 2. Program Cost as a Function of the Quantity of Fixed Resources, k.

Given Q_1, (8) determines the optimal level of the fixed resources, k; and this in turn is used in (4) to yield the time path for the variable resources, X(t).

Substituting (8) into (7) yields total program cost in the planning situation as a function of the variables that prescribe the delivery schedule: Q_1, t_1, V, and T.

$$C = B\, P_k^{\alpha\gamma/(\alpha\gamma+1)} \{Q_1^{(1-\delta)\gamma}[e^{\rho t_1/(\gamma-1)} - 1]^{1-\gamma} + (V^{1-\delta} - Q_1^{1-\delta})^{\gamma}[e^{\rho T/(\gamma-1)} - e^{\rho t_1/(\gamma-1)}]^{1-\gamma}\}^{1/(\alpha\gamma+1)} \tag{9}$$

where $B = A^{1/(\alpha\gamma+1)}(\alpha\gamma)^{-\alpha\gamma/(\alpha\gamma+1)}(\alpha\gamma+1)$

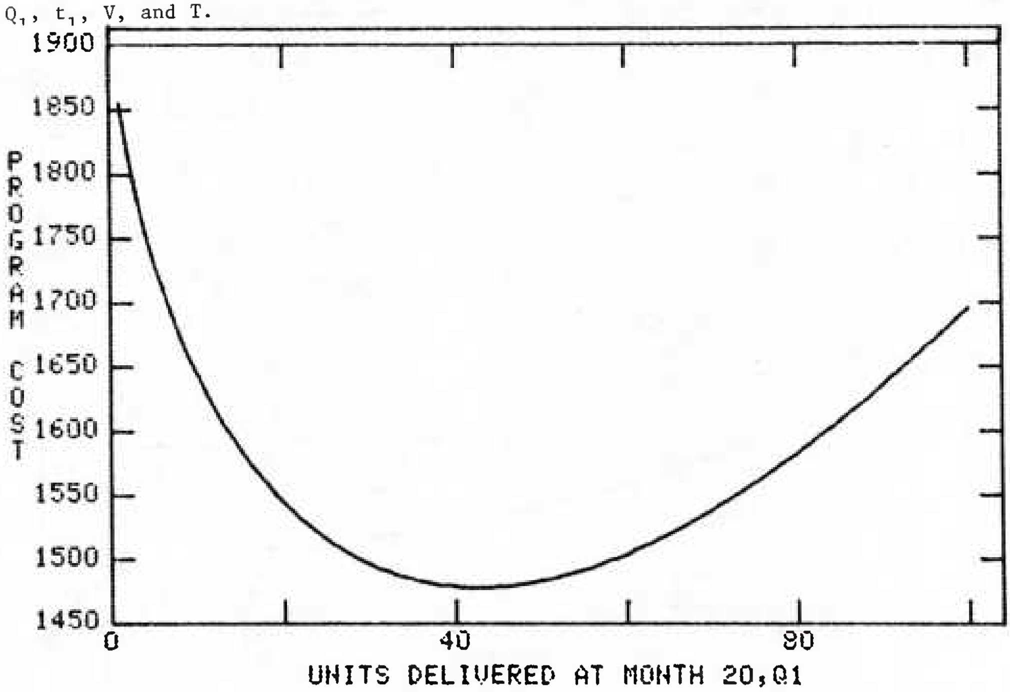

Figure 3. Program Cost as a Function of Delivery Schedule, Q_1.

Figure 4 shows the relation between average costs of production in the planning situation and the production situation. The lower solid curve (the planning situation) shows the least cost way to produce V aircraft in T months. The dot-dash curve shows the production situation corresponding to Q_1 and k. It reflects the costs that will be incurred if V is not equal to its planned value. The two curves are not tangent at V = 240. This reflects the fact that Q_1 was not chosen by the least cost criterion. Nevertheless, k has been chosen so that given Q_1 there is no lower cost way to produce 240 aircraft in T months and satisfy the delivery schedule.

Figure 4 illustrates the impact of either crashing or stretching a program in the production situation. Clearly decreasing V results in higher unit costs than planned and substantially higher costs than could have been attained had the correct volume been anticipated. Likewise, crashing the program, increasing V without changing T, results in higher costs than would have been available in the planning situation. Increasing V may actually increase unit costs if V is substantially greater than planned.

Finally, Figure 4 sheds some light on Smith's [19] results which show that production rate and unit costs are sometimes positively and sometimes negatively correlated. Decreasing V in the production situation results in an exogeneous decrease in production rate and an increase in unit cost. Thus producing a tendency towards negative correlation.

Increasing V in the production situation requires production rate to increase. This too can result in higher unit costs; thus a positive correlation.

Once formed the model can be exercised to analyze the effect of alternative policies on costs and production. The next section provides a sample analysis.

A CONSTANT WORKFORCE

Suppose national economic policy argues that fluctuations in the demand for labor in the vicinity of the contractor be minimized. One possible policy is the constant workforce policy:

$$\ell(t) = \ell \tag{10}$$

That is, the quantity of labor used cannot vary during the program.

There are several possible specifications of the relation between labor, other variable resources and the class of variable resources. One tractable specification is based on the Cobb-Douglas production function.

$$q(t) = k^{\alpha}\ell^{\beta}(t)M^{\varepsilon}(t)Q^{\delta}(t) \tag{11}$$

where $0 < \beta,\ \varepsilon < 1$ and $1/\gamma = \beta + \varepsilon$

Invoking the constant workforce restrictions:

$$q(t) = k^{\alpha}\ell^{\beta}M^{\varepsilon}(t)Q^{\delta}(t) \tag{12}$$

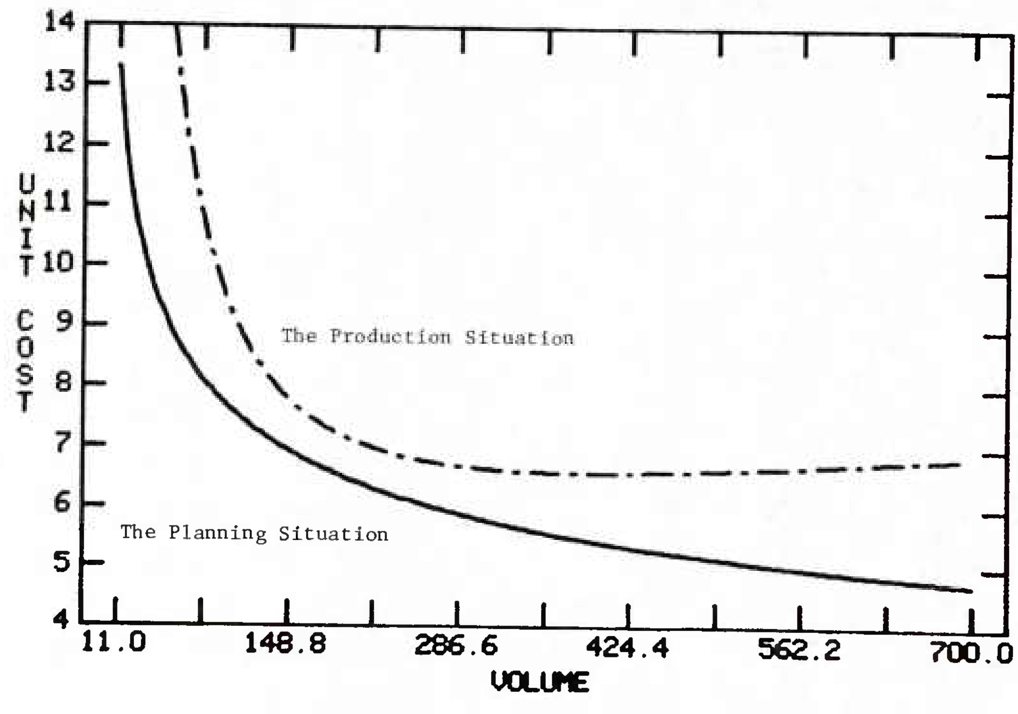

Figure 4. Program Cost as a Function of Volume.

Since neither k nor ℓ can be varied during the program they can be joined to form the composite resource Z, yielding

$$q(t) = Z^{\alpha+\beta} M^{\varepsilon}(t) Q^{\delta}(t) \qquad (13)$$

Writing the production function in this form we see that the constant workforce problem is just like the variable workforce problem except that $\alpha+\beta$ plays the role of α, ε plays the role of $1/\gamma$, Z plays the role of k and M plays the role of x.

The impacts of the constant workforce restrictions are to raise costs and to make the production situation even more restrictive. Now the cost penalties for picking the wrong level of V are even higher. This is illustrated in Figure 5. Here, with $\beta = \varepsilon = 1/4$, unit costs in production situation are superimposed on Figure 4. If the correct volume is planned, the cost penalties of the constant workforce are minimized. But as V changes from its planned level, the cost penalties increase.

SUMMARY AND RESEARCH PLANS

This paper has expanded an earlier model. The expanded model was seen to deal nicely with the problems of producing to a delivery schedule and it incorporates prior experience on the program. The model also permits the analyst to specify certain policy constraints and trace their implications on program costs. More importantly, the expanded model is seen to contain an explanation for the fact that sometimes production rate has been positively and sometimes negatively correlated with program costs. However, to verify this hypothesis more work needs to be accomplished.

In particular a careful job of estimating the cost function for several airframe programs needs to be done. This requires attention to the kinds of policy constraints in force at various times during the program. Fortunately much of the required data is still available.

In addition to the data sets reported by Smith (20) and Orsini (15) data from OSD reports like "Acceptance Rates and Tooling Capacity for Selected Military Aircraft" (4) and detailed program histories in the ASD Cost Library can be consulted. Interviews with contractors may also be required. While little raw data is expected to be required, the data sets need to be consolidated and transformed to provide consistent observations. The parameters of the model can be estimated for each airframe program. Finally, the estimated model can be programmed and used to provide timely, documented answers to questions about the cost impact of alternative policies.

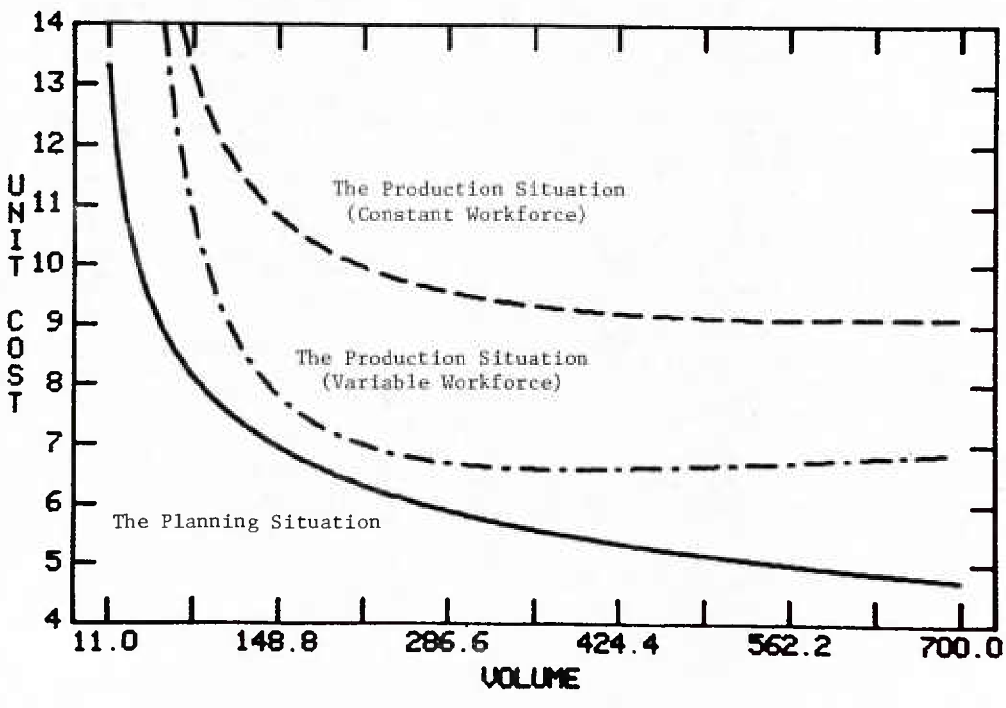

Figure 5. The Impact of a Constant Workforce.

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A GENERALIZED APPROACH TO THE IMPROVEMENT CURVE

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ABSTRACT

Simplistic linear improvement curve ideas continue to mislead procurement and contractor personnel in planning, pricing, negotiation and management of acquisition costs and delivery schedules. It is time to recognize in concrete terms that the traditional "learning curve" concept is only a "baseline" on which several complex irregularities parade their peculiar and expensive characteristics. Moreover, there are profound interrelationships among them, which suggest the presence of even more basic causal factors. Further consideration produces a list of about sixteen causal factors. These are not only helpful in understanding the major irregularities, but also provide a more fundamental framework of analysis. In turn, that framework offers great potential to improve the planning, estimating, and control of manufacturing labor and to develop a far more comprehensive computer model of labor hours. Such a model is being developed. It should be helpful to procurement analysts and contractors both in their individual activities and in communicating with each other.

THE LINEAR IMPROVEMENT CURVE

Early Simple Concepts. As is generally known[(1)], in the late twenties it was observed that the costs of Army aircraft could be roughly described by a log-linear formula, and the approach quickly developed substantial interest in the aircraft industry. The first formal paper on the subject, by Wright in 1936, described these useful insights in terms of a cumulative average pattern. That pattern maximizes the linearity of cost experience but smothers important information contained in the many deviations which occur. Several years later the more sensitive incremental or "unit" approach was introduced by Crawford of Lockheed Aircraft.

Both parties proposed that the pattern was linear and that it followed a slope of 80 percent for manufacturing labor. It was recognized that material cost probably followed a substantially shallower slope, such as 90 or 95 percent. The approach was very attractive. While it introduced a rather sophisticated notion to the hitherto strictly Euclidean space of cost accounting, it employed simple straight lines plotted on log-log chart paper. Even an executive could use a ruler and pencil.

At the same time, this very simplicity could be misleading, as suggested by the three graphs shown on Figure 1. Examples A and B show actual manufacturing labor data. To indicate its non-linearity, a linear trend has been drawn through the points: note the slopes of 71 percent and 75 percent. But also note that the accuracy of the fit is only sixteen percent and fifty percent respectively.[(2)] Example C of Figure 1 shows the result of a linear 80 percent slope, the values of which have been randomized within a reasonable range around the central tendency. The linear trend here has a slope of 82 percent with an accuracy of 44 percent, much better than for the real-life data in Example A. Obviously reality can be far more complex than the ordinary approach to improvement curve analysis suggests.

We might, in fact, think about labor performance as involving a substantial band of uncertainty rising from a baseline which defines a basic tendency for costs to reduce as production continues. The baseline, however, cannot prevent substantial increases from occurring between two adjacent segments of unit performance. To achieve economical cost performance we must at least understand the sources of variation, the likelihood of their occurrence and their probable patterns.

Toward this end, we will now review the many sources of apparent and real non-linearity in production labor hour performance. We shall then construct a broad framework to use in describing and estimating such costs. Subsequently we will outline the structure of an interactive computer program now being developed to implement the approach.

Elaboration of the Basic Hypothesis. It was not long before the original simplistic hypothesis was forced to deal with a number of exceptions discovered by closer study and application of the idea to real situations. Generally, it was found possible to save the theory by interpreting deviations in cost from the linear pattern as representing mere special applications. For example, two interesting situations involved major design changes and the effect of interruptions to continuous production. We don't seem to know who first studied these, but the results have long been accepted by subsequent analysts.

Design changes, or task changes to be more general, cause a substantial penalty in unit cost for a

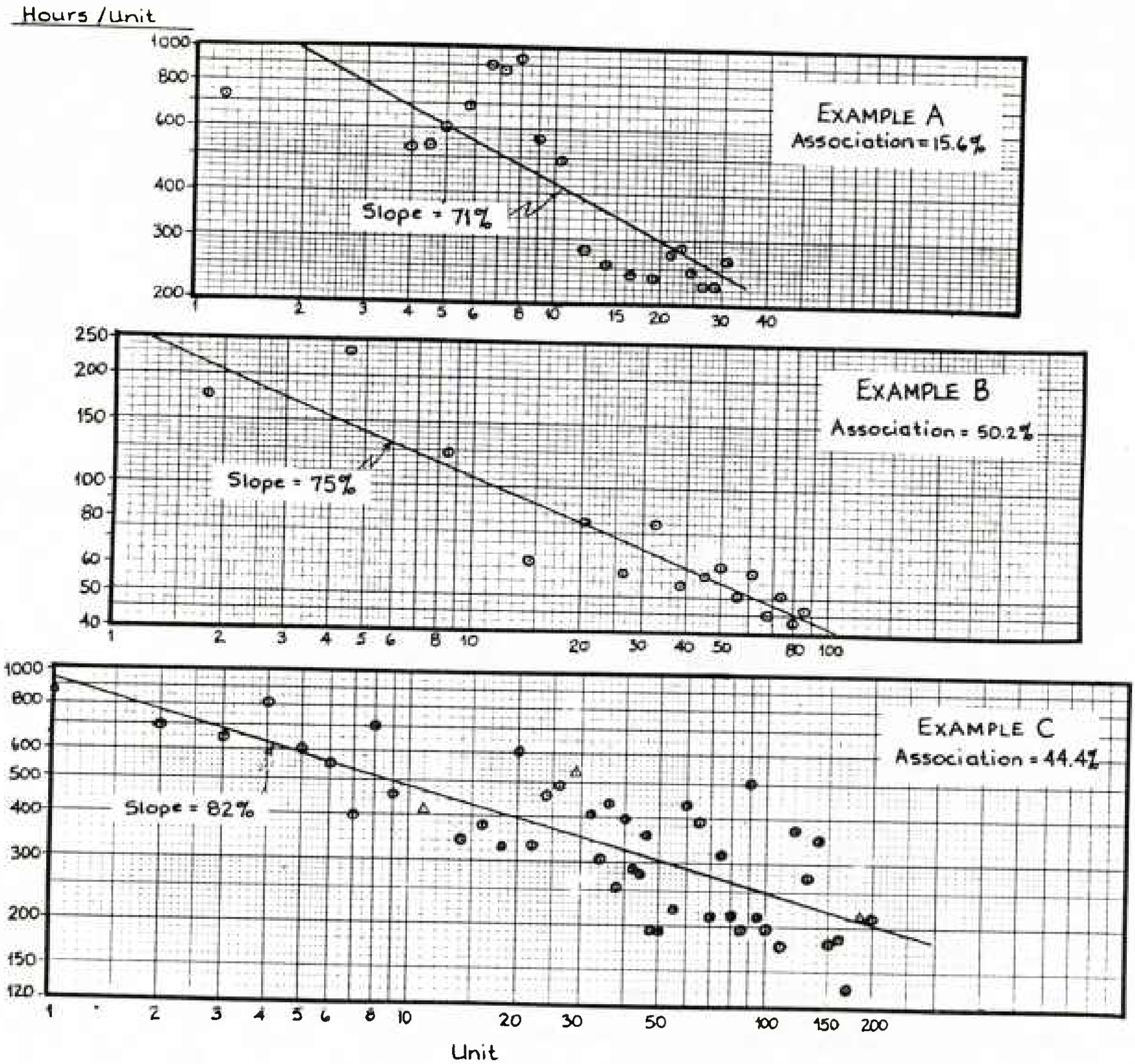

Figure 1. Typical Labor Hour Patterns

number of units. This was interpreted as the result of imposing a brand new task, the cost of which is related to its own unit sequence. Naturally that requires a substantially higher cost for a given amount of work performed, than for other work which is already down the cost curve by fifty or a hundred units. In similar manner, the cost increase occurring upon resumption of production after a significant interruption was interpreted as the result of a loss of learning. reproducible by a simple "retrogression" of unit cost back to the value for an earlier unit. This provided an increase in cost, the amount of which was determined by the degree of retrogression. In neither case, it must be emphasized, was there precise statistical substantiation of these hypotheses. But they were reasonable, and made it possible for the first time to come to some sort of terms with the difficult problems they addressed.

In 1946, G. Carr of McDonnell Aircraft suggested that acceleration of production by bringing several crews into operation over a period of time would generate a higher cost each time. The idea had some merit and again the linear hypothesis was maintained, but the amount of non-linearity introduced in this way was too small to help in assessing early cost patterns.

In 1952(3) it was recognized clearly (for the first time apparently) that the magic 80 percent slope itself had to be abandoned. There seemed no doubt that different slopes typified different types of manufacturing operations, and that generally those which had more machining displayed shallower slopes, such as 90 percent or 95 percent. Ultimately it became accepted that the amount of slope is related to the degree to which the work is man-paced, or oppositely, machine-paced.

In 1949, Stanford Research Institute addressed the curious phenomenon that early costs of WWII aircraft seem to start below the backward extension of the subsequent linear pattern. This, they

opined, was the result of carry-forward learning on the part of manufacturers having previous experience in aircraft production. Thus they could, in varying degrees, bypass the front-end costs of the learning curve. The notion has considerable attractiveness in certain circumstances, though some analysts have questioned the adequacy of its statistical foundation. It also seems erroneous in terms of today's knowledge of the startup costs of manufacturing new high technology products, as we shall describe below. Nevertheless, the idea focused the attention of aircraft industry analysts on the potential for non-linear patterns, and so made an important contribution.

Attention to non-linear patterns was enhanced in 1956 by Harold Asher's wide-ranging review of practices and theories of improvement curve analysis. At the same time he noted that the presence of several slopes in a manufacturing operation could explain a tendency for some cost experience to show some leveling as production continues. The leveling would result simply by the more rapid reduction of assembly labor (which has a sharper slope than machining or sheet metal labor) to become a smaller proportion of total man hours.

It might also be noted that industrial engineers concerned with short cycle or mass production activity, were rather unhappy with the idea of a long-lasting improvement curve. To them, it challenged their cherished idea of a permanent labor standard reflecting the "one best way" of organizing and performing a task. In 1953 one analyst even proposed a non-linear improvement curve model which approached a lower limit asymptotically(4) in an attempt to reconcile short cycle standards with the linear improvement curve theory.

One further idea was developed in 1959(5) to further improve the flexibility of the linear hypothesis, though its proposal was conjoined with a throughly non-linear proposal to be discussed later. At that time the idea of "rate of learning" was suggested to formally recognize the effect of producing several components for use in each major end-unit. For example, in a transport aircraft there might be four power pods so that 200 aircraft would require 800 power pods. The cost effects could be very substantial, and should a manufacturer fail to take this into consideration in bidding, or in negotiating purchase of components, he could be seriously embarrassed.

It was also pointed out that there are significant opportunities to exploit this idea in the organization of the production process itself and in the design of modular sub-components. Carr's 1946 proposal concerning multiple crews actually produced permanently higher cost because of the lower rate of learning which they caused.

THE EVOLUTION OF TRUE NON-LINEARITY

In the 1950's there was growing interest in the improvement curve by an expanding United States defense industry, encouraged by improving methods of cost accounting. By the end of that decade a stream of new cost improvement concepts began, most of which involved substantial elements of basic non-linearity. The flowering was undoubtedly aided by the rapid growth of operations research techniques, use of computers and attention by business schools to quantitative methods.

New Product Introduction. In 1959 it was observed(6) that labor hours expended on units produced in the early part of a production sequence are often much greater than would be expected by a backward extension of the ultimate linear improvement slope. Analysis of operating conditions during such periods, especially with high technology products, made it clear that numerous influences exist which disappear as manufacturing activities become more normal. Chief among these influences are the need to de-bug new tooling and methods, shortages of parts and equipment as a result of design delays and changes, extensive rework and retrofit activities due to design changes and the difficulties met in developing a new production team.

Some of these phenomena might be explainable in terms of linear cost concepts. But it is impossible to overlook the totally non-linear character of many cost events at this time, and especially those defined by the interference and compounding effects of work performed with utmost urgency to meet a tight delivery schedule prescribed many months or years earlier. At such a time it is almost impossible to foresee the numerous surprises which development and introduction of a new design might bring; nevertheless, competitive bidding requires firm delivery commitments to be made then.

Figure 2 illustrates the pattern. First, it shows actual data on a major jet aircraft. Second, it shows an idealized version of an S-Curve plotted from computer output; this processing adapts the pattern to various unit durations and degrees of intensity above the linear baseline. The essential part of these curves is that there is a substantial amount of cost above the normal linear curve during product introduction, regardless of what may happen later on. Subsequently, of course, many things can also occur later to distort the simple linear curve. As Figure 1 showed, this can make it impossible to determine by simple curve fitting what that underlying pattern is.

Four major factors in early labor performance deserve mention: (a) initial production startup, (b) design delays and changes, (c) production delays and (d) various compounding processes. Briefly, production startup involves the need to train substantial and growing numbers of people on-the-job, the difficulties of accelerating production of a new design for the first time, balancing acceleration output rates of several departments operating on different improvement slopes, breaking in tooling and facilities and the inherent inefficiencies of early low production rates.

Design changes frequently occur due to the "concurrency" of design, test, tooling, procurement and early production operations which often occurs

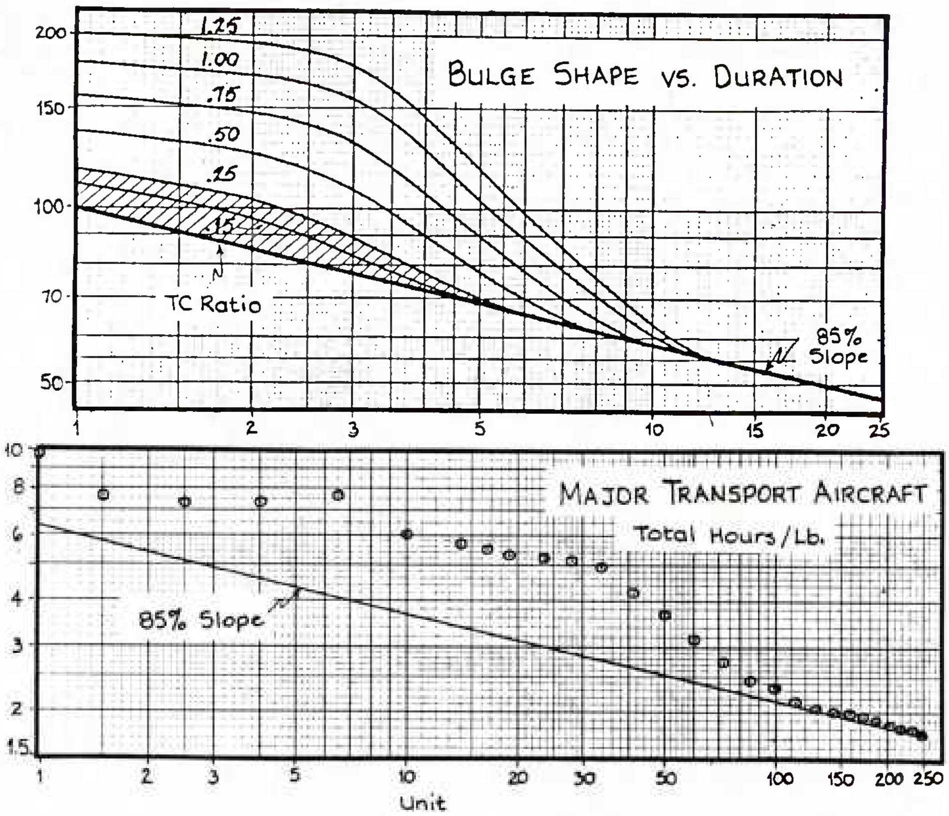

Figure 2. Early Product Costs

when a new design is introduced under a tight time schedule. This produces surprises well after subsequent stages of tooling and procurement have begun and there are many cost penalties including loss of learning, rework, repair and retrofit of units already made or partially completed. Moreover, the situation generates numerous delays to designs and to production components and equipment. In turn, these slow down work in the shop and require transfer of people to other tasks with associated loss of learning and extra training, followed by subsequent acceleration. Compounding effects are legion.

Subsequent use of the S-Curve idea stimulated explication of various events which might help explain the shape of the bulge and the interrelationships within it. Most of the results turned out to have application elsewhere as well.

Learning vs Progress. One concept involves a distinction between the portion of improvement in labor hours due to "learning" and that due to "progress".(7) Recognizing that learning is a complex result of the individual worker (and the pacing of his equipment), his supervision and many support services, there is ample room for continual creeping methods improvements. However, it seems logical to identify the rather distinct phenomenon of major methods improvements which might be incorporated from time to time.

In products involving advanced manufacturing technology, such major improvements often occur periodically over a number of years. This causes occasional unit segments to show a rate of cost improvement substantially sharper than the ordinary "learning" slope, and even over the entire production run the composite slope would be affected. Of course, the events that produce progress improvements may themselves introduce cost penalties which take time to work out.

All this provides a potent source of non-linear cost performance anywhere in the production sequence. But there is another aspect which contributes directly to the initial bulge in hours. That is, under tight deadlines there is a tendency to start production with incomplete tools and even drawings, and this is intensified by the design delays and changes which often occur. That makes the actual task being performed much harder on early units than it will be later - for example, hogging out parts for which forgings are not yet available. This raises the cost of unit one well above that defined by the basic learning slope. The difference can only be eliminated by a series of progress improvements over a number of units, and that generates a collateral series of perturbations as appropriate methods changes are introduced.

It is possible to separate the learning and progress vectors so as to define a distinct slope for each, with the actual slope being the composite product or resultant. This shows the danger in assuming that the composite slope of past experience will continue on future products. For achiev-

ing that goal requires a similar technological opportunity together with the willingness to invest in manufacturing engineering, rearrangement and new equipment. The first will be far less likely when the product is closely related to its predecessor and the cream of the improvements have been skimmed off. The second is less likely when the total quantity to be produced is less. Obviously the reverse of each of these might also be true, in which case a sharper progress (and composite) slope is appropriate. Calculating the cost premium imposed by design changes and production interruptions is also affected. For since that premium represents the cost of lost learning only, it is necessary for these computations to use only the shallower learning slope.

Manpower And Task Changes. It was further found that costs of changing manpower assignments could be modeled in similar fashion to an estimate of design change cost.(8) Such categories as additions, reductions, reassignment and turnover warrant attention. And while these calculations employ the linear improvement curve idea, the sporadic but repeated nature of manpower changes in a new product introduction, or later on in the sequence, imposes further non-linearity on the overall cost curve.

It was also recognized that the introduction of a change in task (due to either methods or design change) creates imbalance in the size of the tasks assigned to interdependent workcenters. For even though one workcenter's task is raised by a substantial change, with its corresponding retrogression to earlier unit cost levels, that group still must complete its work in conformance with the needs of its associates. The resulting interferences and delays could generate substantial additional costs, for which the usual change cost allowance does not provide. One way to allow for this uses S-Curve patterns for calculating the work of crews so affected. Some delays might be avoided by adding manpower to help the group whose task is revised; of course this introduces training penalties.

We should also consider the non-linear pattern of costs defined by queuing analysis(9). Thus, several workcenters performing interrelated tasks might experience idle time due to simple variability in the cycle times accomplished by other workcenters, due to various problems associated with new production introduction. Such a condition is especially likely where the size and complexity of the product mitigates against building substantial work in process inventories to act as float.

The pattern of cost penalties for personnel being trained on-the-job is also of interest. The duration of such training is generally related more to time than to unit output, though the latter may also be important. Thus the inefficiency penalty cannot shrink in conformance with a log-linear pattern, which again introduces a fundamentally non-linear element.

Production Rate. Learning curve analysts have always been interested in how production rate effects the cost reduction pattern. This is not the place for a comprehensive review of the subject, but it may be said that the early tendency to assume that rate of production inherently affected slope was an over-simplication. However, it is true that a change in methods or R/L associated with a revision in production rate could, for the period of time required to make the adjustment, cause a different slope than before or after.

It was also evident that the need for key skills in a given production activity meant that a change in output level would not usually be accompanied by a comparable change in the total number of people. Thus one might view the direct labor staff as following a linear function in which key personnel are represented by the coefficient "a" in the formula $h = a + b \cdot r$, where r measures the output rate and the entire amount of h is then subject to the usual improvement pattern.(10) We must also recognize that a reduction in labor cost per unit when rate goes up may not occur when the plant is operating near its limits of space, people, machines, etc., or when new tooling and personnel must be added. And lower rates may not produce higher unit costs if high-cost operations are shut down or mainly less skilled personnel are laid off.

The actual procedure of accomplishing a substantial change in production rate can pose a complex management task. Significant changes in many areas may be required: plant layout and organization; inventory procedures and warehousing; shop organization and operational procedures; the sharply different level of operating personnel may cause all kinds of difficulties, not to speak of the very process of acquiring or deleting large numbers of people. The event may have a lasting effect on the facilities organization and operating procedures, and it may not be possible to recover the original arrangements when the rate change is reversed. Major rate changes have hysteresis effects.

In 1976 an important statistical study by L. Smith(11) focused attention on production rate. Smith proposed a log-linear model which used the unit sequence as one variable and production rate as a second variable by which to determine unit cost (in man hours). An exponent in the vicinity of -.20 was found to fit several major cases, which implies that doubling production rate reduces unit cost about thirteen percent. Given the rather frequent changes in unit rate which occur from beginning to end of a product life, this one factor alone will produce substantial non-linearities in the cost improvement curve.

Incidentally, a thirteen percent reduction in unit cost by doubling the rate is also achieved by a linear model in which approximately 26 percent of the initial personnel are semi-variable or "fixed". As for any model which attempts to describe complex organization behavior, the specific operating circumstances must be carefully assessed before selecting the formula to be used.

Product Phaseout. One phenomenon which seems to have long been recognized is the question of

"tailup", or what happens at the end of the production sequence as production is wound down. Rather little has been published on this topic, perhaps because of its relatively small share of total program cost. However it can be extremely important as a proportion of the final lot of units being produced, or in terms of unexpected costs to be absorbed as a result of early termination. Following a substantial review of such circumstances in 1972, a paper was prepared which explored the key ingredients(12). The results revealed a surprisingly complex situation, which was not only non-linear but suggested interaction among several causal events much as was found to occur during new product introduction. These conclusions were expanded by further review in 1979(13).

Several major areas exert significant influence on the pattern of labor hours during project phaseout; each in turn comprises a number of important influences. The main categories include: parts shortages, personnel effects, cessation of progress, shrinking production rate, and interruptions. The complexity of all this is indicated by the further listing shown in Table 1.

Production Interruption Revisited. The simple "retrogression" model of production interruption cost has severe limitations. For example, in 1967 it was suggested that, as for ordinary learning, increasing numbers of repetitions (reinforcement) should reduce the drop in efficiency (and so the amount of retrogression) which occurs after an interruption(14); a practical way of using the idea was also presented. It was also noted that the recovery pattern defined by proceeding down the set-back sequence one unit at a time usually took too long, and more rapid recovery patterns were proposed which eliminated any semblance of linearity in the model.

In addition, the traditional retrogression procedure focuses on the number of units for which retrogression is to occur. This seems rather obtuse, since the real question concerns the amount of learning already accomplished which is to be reduced. Moreover, the exponential factor which links a unit's position in the production sequence with its cost has a small value, generally 0.35 or less. This causes a serious disproportion between the degree of retrogression and the cost penalty it produces. For example, a retrogression from unit one hundred to unit fifty - one half - on an 85 percent slope eliminates only nine percent of the learning already accomplished on unit one hundred.

A more concrete, and indeed credible, approach is to focus on the amount of cost improvement already accomplished and deal with its loss in terms of "forgetting". This kind of measurement was inaugurated as early as 1885 by a psychologist concerned with learning theory. An application to labor hours was suggested in 1972 by Kerkhoven. Another by Carlson and Rowe in 1976 proposed a forgetting function which calculates the loss of learning in terms of (a) the production rate achieved prior to interruption and (b) the duration of that interruption.(15) Combined with other refinements, this method has given useful results in several tests, but it is still based heavily on the single parameter of time.

Thus, while these improvements are useful, they still do not fully recognize the complexity of a major interruption. It can be a most costly event. The period leading up to a suspension of operations may involve all the complexities of a full-blown product phaseout. Depending on how long production is suspended and the design and methods changes injected upon resumption, we may then have something like a new product introduction with all the problems of acquiring and training personnel, refurbishing tooling, starting up, and developing a going operation; often at a lower production rate than before.

It may even be that the passage of time has produced substantial improvements in production methods (progress), so the resumption of activi-

Table 1: FACTORS IN TAILUP OF LABOR HOURS

1. Parts Shortages
   - o Replace/rework parts rejected earlier.
   - o Remanufacture parts to replace those cannibalized earlier.
   - o Smaller lots reduce safety margins.

2. Personnel Effects
   - o Crew reductions require task reallocation.
   - o Bumping requires multiple job reallocation.
   - o Best people sent elsewhere.
   - o As shutdown approaches, the pace slows down and morale declines.
   - o Increasing turnover requires on-job training.
   - o Selective retention of skilled people beyond basic needs.

3. Cessation of Progress
   - o Technical personnel transferred.
   - o Tooling and equipment transferred.
   - o Remaining production cannot amortize the investment required.

4. Shrinking Production Rate
   - o Key jobs can't be cut in same proportion.
   - o The rhythm of assembly crews is affected.
   - o Smaller lots raise set-up cost.
   - o Smaller crews require more movement.
   - o The process of reduction generates confusion & cost penalties.

5. Production Interruptions
   - o Planned: to combine runs.
   - o Sporadic: occurs at low rates due to shortages, low priority of the work, etc.

ties may be at a lower basic cost level. This does not necessarily mean that the initial cost level will be lower, since it must reflect the various disruptions involved in startup. However, where individual product cost variances are routinely spread by the cost accounting system over a variety of other products, there may well be such an early reduction in accounted cost, as reported by Cheney for a number of cases involving avionics navigation equipment[16].

General Modeling. And lastly, there has been extensive work to develop computer models of the complex events involved in new product introduction[17]. Many of the events modeled also occur in phaseout, interruption and design changes. One of the more useful tools developed during this work was that of a series of cost penalty functions which could be used to approximate the complex cost consequences of the various individual events which were clearly occurring.

PRESENT STATUS

Over the last twenty years an impressive array of non-linear labor cost phenomena and estimating methods has been explored. We should now be able to summarize this material and construct an analytical framework which handles all of it in an orderly and useful manner.

The Main Irregularities. It seems fair to conclude that actual unit labor hours are normally very non-linear and irregular. Somewhat similar statements have been made before, but they have usually referred to less extreme variations, and certainly have not been implemented in any comprehensive manner. We seem now to be in a position to do that.

The situation is well expressed in terms of a baseline, to which five basic irregularities add impressive complications. These irregularities are: startup, rate changes, task changes, interruption and phaseout, and were adequately described earlier. Under suitable conditions, any one of them can generate an increase of fifty percent in unit cost above the stable baseline.

Given the frequency with which they can jointly affect a given program we are justified in referring to the aggregation as a "higgledy-piggledy improvement curve". And that is the norm. Thus, we can now apply to the entire unit sequence a description which, when written in 1967, referred only to the product introduction phase[18]:

> "A search for the 'one best shape' is inherently doomed. For...any one set of unit cost data must reflect the special circumstances of its design and production. The cost trend simply mirrors those conditions, and will therefore bulge and drop and twist excruciatingly."

Most discussion of the five irregularities treats each separately. This is misleading, for there are important relationships among them, some of which we have already noted. For example, a low production rate is much involved in startup activities and its acceleration contributes importantly to the rapid reduction in cost shown shortly thereafter, much as decelerations contribute to the cost increase during a phaseout. Task changes (both design and progress) may also be important in startup. A major interruption can involve all the problems of a phaseout, followed by an extensive delay during which personnel and facilities are reassigned or discarded. This is succeeded by the unique problems of a startup, including perhaps some changes to design and methods.

At the same time, it is evident that these five irregularities are not the ultimate causal factors. We have previously recognized, for example, that both startup and design changes may also involve tool debugging, on-the-job training of new people, interference between crews, and rework. Phaseout is affected by increased personnel turnover. And so on. It is sometimes suggested that these irregularities be handled as segmented linearities. This begs the question, for we must still determine what causes the jump from one slope to another and the degree of change in that slope. We cannot escape the need to identify the basic modules from which the irregularities are constructed.

Basic Causal Factors. The sixteen factors selected are listed in Table 2, with indication of the major irregularities each one affects. Note that rate changes are divided between acceleration and deceleration. Also, Task Changes appears both as an irregularity and as a causal factor.

We must also recognize that most of the sixteen factors themselves have interrelationships, as shown by Table 3. These are very important in constructing a scheme by which to use the factors to estimate the costs of a major irregularity, and we must define them carefully. Hence, the following briefly describes the manner in which each of the sixteen causal factors directly affects the others. Obviously if all second and third order effects were traced, a single factor can ripple through a majority of the sixteen, making the final impact too complex to discuss.

1. Degree of man-pacing (production slope) is the fundamental improvement curve slope determinant and as such defines the rate at which cost is reduced from unit to unit. As a result it has an effect on Factor 3, production rate, since rate tends to change inversely with the cost level, given a constant crew size. In addition, it affects Factor 15 (loss of learning), since the amount of learning already accomplished is determined by the basic slope and the number of units produced.
2. Position on the unit sequence also has an important effect on production rate and loss of learning (Factors 3 and 15) because it determines, jointly with slope, the level of unit cost. That cost affects rate (inversely) and determines the amount of learning achieved to that point, which is subject to erosion by other events of interest.
3. Production rate impacts several areas. First, it affects basic personnel efficiency (Factor 4)

Table 2: CONTRIBUTING FACTORS IN MAJOR IRREGULARITIES

	Contributing Factor	Major Irregularity Produced					
		A	B_1	B_2	C	D	E
		Startup	Accel-eration	Decel-eration	Task Change	Inter-ruption	Phaseout
1.	Degree of man-pacing (production slope)				X	X	X
2.	Position on unit sequence				X	X	
3.	Production Rate	X	X	X		X	X
4.	Basic personnel efficiency and on-the-job training time	X	X		X	X	
5.	Debugging of tools/methods	X			X	X	
6.	Support services: supervision, materials, equipment, etc.	X	X		X	X	
7.	Delays: tools, design, personnel, materials, etc.	X	X		X	X	
8.	Task Changes						
	o Progress: task reduction	X			X		X
	o Configuration Changes	X			X		
9.	Personnel: turnover, morale			X		X	X
10.	Rate of learning: no. of crews, shifts, lines; parts used/unit	X	X	X			X
11.	Task re-assignment				X	X	X
12.	Work force increases	X	X				
13.	Work force reductions			X			X
14.	Lot size changes	X	X	X			X
15.	Loss of learning				X	X	
16.	Rework and retrofit	X			X		X
		11	7	5	11	10	9

since a substantial and consistent production rate contributes to good rhythm and morale while a halting and inconsistent rate generates idleness and lost time. It also encourages progress due to task reduction (Factor 8) because a substantial production rate can absorb larger investments in tooling and method changes than can a smaller one. Third, a higher production rate tends to affect the rate of learning (Factor 10): on the one hand it may reduce R/L by an increase in the number of crews; on the other, it may increase R/L by allowing greater subdivision of the work into smaller modules used in multiple quantities on each end-unit. Fourth, production rate obviously affects the number of personnel assigned to the work, represented by Factors 12 and 13. In addition, production rate will influence the selection of lot sizes, Factor 14.

4. Basic personnel efficiency and on-the-job training time affects production rate (Factor 3) and places a greater demand on support services (Factor 6). In addition, poor efficiency may increase the amount of rework and retrofit work (Factor 16).

5. Debugging of new tools and methods is generally most important in the early stages of production, but it occurs for any major design or methods change. It will generally make substantial demands on support services (Factor 6) and require at least temporary reassignment of personnel (Factor 11). There will often be loss of learning due to replacing old tasks by new ones (Factor 15) and a general likelihood of extensive rework and retrofit (Factor 16).

6. Support services involve supervision, material, equipment, etc. Their adequacy will strongly affect the rate of production (Factor 3), the rapidity with which new tools and methods are debugged (Factor 5) and the rate at which new methods and design refinements produce progress (Factor 8).

7. Delays can affect a variety of production areas, such as tools, design, personnel, material etc. In so doing it will certainly affect production rate (Factor 3) with results for efficiency (Factor 4). In addition, it often requires temporary work force reassignment and reductions followed by corresponding increases later (Factors 11, 12, and 13).

8. Task changes. Progress changes are generally made to reduce the task while configuration changes as such are made for engineering and marketing reasons. There can be some differences in their effects. Progress can affect production slope (Factor 1) as operations are increasingly mechanized, may well cause increases in the rate of learning (Factor 10) and will often produce work force cuts (Factor 13). Design changes, on the other hand, will generally require rework and retrofit tasks to be performed (Factor 16). Both types of change will generally require debugging of tools, etc., special attention from support services, reassignment of some work and often a significant loss of learning (Factors 5, 6, 11 and

Table 3: CAUSAL FACTOR RELATIONSHIPS

	Contributing Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL
1.	Degree of man-pacing (production slope)	–	–	X	–	–	–	–	–	–	–	–	–	–	–	X	–	2
2.	Position on unit sequence	–	–	X	–	–	–	–	–	–	–	–	–	–	–	X	–	2
3.	Production rate	–	–	–	X	–	–	–	X	–	X	–	X	X	X	–	–	6
4.	Basic personnel efficiency and on-the-job training time	–	–	X	–	–	X	–	–	–	–	–	–	–	–	–	X	3
5.	Debugging of tools/methods	–	–	–	–	–	X	–	–	–	–	X	–	–	–	X	X	4
6.	Support services: supervision, materials, equipment, etc.	–	–	X	–	X	–	–	X	–	–	–	–	–	–	–	–	3
7.	Delays: tools, design, personnel, materials, etc.	–	–	X	–	–	–	–	–	–	–	X	X	X	–	–	–	4
8.	Task Changes																	
	o Progress: task reduction	X	–	–	–	X	X	–	–	–	X	X	–	X	–	X	–	7
	o Configuration Change	–	–	–	–	X	X	–	–	–	–	X	–	–	–	X	X	5
9.	Personnel: turnover, morale	–	–	–	X	–	–	–	–	–	–	–	–	–	–	X	–	2
10.	Rate of learning (R/L): no. of crews, shifts, lines; usage/unit	–	X	–	–	–	–	–	–	–	–	X	–	–	X	–	–	3
11.	Task re-assignment	–	–	–	X	–	–	–	–	–	–	–	–	–	–	X	–	2
12.	Work force increases	–	–	X	–	–	X	–	–	–	X	X	–	–	–	–	–	4
13.	Work force reductions	–	–	X	–	–	–	–	–	X	X	X	–	–	–	–	–	4
14.	Lot size changes	–	X	–	–	–	–	–	X	–	–	X	–	–	–	X	–	4
15.	Loss of learning	–	–	–	X	–	–	–	–	–	–	–	X	–	–	–	–	2
16.	Rework and retrofit	–	–	–	X	X	X	–	–	–	–	X	X	–	–	–	–	5
	TOTAL	1	2	7	5	4	6	–	3	1	4	9	4	3	2	8	3	62

15).

9. Personnel factors. Turnover requires replacement of trained with untrained or lesser trained personnel, thus creating a loss of learning and requiring possibly significant on-the-job training time for the new personnel (Factors 4 and 15). Deterioration in morale may occur during phaseout of a product or in connection with the turbulence of a major disruption, to produce an increase in the rate of turnover along with a tendency to drag the work out (Factor 4).

10. Rate of learning. Changing the number of crews performing the same task or the number of identical parts used per end unit will, for those items, change their position on the unit sequence (Factor 2). The process may involve remethodizing, task reassignment and changes in lot sizes (Factors 6, 11 and 14).

11. Task reassignment will often require on-the-job training time (Factor 4) while causing significant loss of learning (Factor 15).

12. Work force increases will obviously lead to some combination of an increase in production rate (Factor 3) and a reduction in personnel efficiency, with the resulting increase in on-the-job training time (Factor 4). It may well place heavy demands on support services, especially supervision, change the rate of learning through requiring more crews and require substantial reassign ment of tasks (Factors 6, 10 and 11).

13. Work force reductions will force a corresponding change in production rate (Factor 3) and may cause considerable reassignment of tasks (Factor 11) with its own ripple effects. It may also reduce the number of crews performing the same task, thus raising the rate of learning, and will often affect personnel morale and turnover (Factors 10 and 9, respectively).

14. Lot size changes. Larger lot sizes require less frequent reassignment of personnel (Factor 11) while allowing each lot to run farther down the improvement curve (Factor 2) which also reduces the loss of learning (Factor 15). Moreover, it cuts the total task (Factor 8) by eliminating setup time.

15. Loss of learning (as from a design change, for example) may require on-the-job training time (Factor 4). As a secondary effect, it may require increases in the work force (Factor 12) in order to avoid changing the production rate; naturally this has further effects.

16. Rework and retrofit work involves the imposition of a brand new (and often extremely costly) task and has somewhat similar effects. For example by affecting basic personnel efficiency it may require on-the-job training time (Factor 4). It may also require debugging of tools and methods and heavy support services (Factors 5 and 6). And it may require reassignment of tasks, often to the most skilled personnel, and require work force increases to avoid reduction in the overall production rate, with all the consequences involved (Factors 11 and 12).

THE PLANNING MODEL

The approach is to develop a general purpose computer program which estimates the labor hours for each major event or irregularity, using the sixteen causal factors defined above. The program is being

designed as an easy-to-use interactive procedure for contractors, procurement analysts and others directly associated with planning, estimating and evaluation of major acquisition programs. All important methods used have been previously tested.

While this modeling program goes far beyond the usual improvement curve estimating techniques, it is not a complete simulation technique. For example, it does not contain a detailed network of the production activities. Such a model has been previously developed(17), but it still requires a good deal of time and expense to adapt it to a specific situation, though eventually these should be reduced substantially.

General Characteristics. The cost calculations for each irregularity are developed from the basic factors which apply to them (see Table 2) and their interrelationships (Table 3). The user is asked only the most pertinent questions, and the program employs the answers in defining the model, all subject to user approval.

The user's plan can involve several departments, each operating on its own learning slope and subject to its own delivery schedule. This has the important advantage of introducing time-phasing of production and other events as well as a limited amount of interrelationship between departments. A second feature is that the program draws its labor supply from a "pool", which contains limited numbers of people at specified skill levels and restrains the rate of hiring. Third, upon hiring, each skill level is subject to on-the-job training requirements; this causes specified efficiency penalties, subject to decay rates, during the early months.

Fourth, is a personnel turnover function which, with requirements set by the production schedule and the current level of personnel efficiency, periodically determines the need for new personnel. Fifth, the program defines optimum ranges of the manpower which can be productively employed by a given department. There are also penalty functions to measure the cost of approaching and violating those limits, and constraints on the rapidity with which new people can be put to work.

With these basic considerations defined, it is necessary to specify planning data for each department in the plan under preparation. For concreteness this is handled in terms of our basic irregularities: startup, production rate, task change and phaseout. No provision is explicitly made for production interruption, since that category is handled strictly in terms of the others: any interruption requires a phaseout of production, some time interval before resumption and a startup. A specific production interruption subroutine is also provided for more limited estimating purposes.

Predicting The Cost Of Irregularities. Predicting startup cost requires specifying the initial design and methods penalty above the underlying slope, together with the time or units required to eliminate that penalty and the turbulence associated with this progress. Second, there must be a penalty pattern for the cost of debugging tooling and methods. Third, we must allow for the instability of design which often occurs during new product introduction. This requires an allowance for addition of new tasks and elimination of old ones. The net difference in basic task size can vary up or down, and the time shape and unit tailored to suit available experience and anticipated events.

In the startup phase we must also provide rework and retrofit, the amount depending on the character and timing of the changes introduced and the number of units requiring the work. Lastly, we must consider the impact on basic efficiency of delays in tooling and components. It is unlikely that these can be predicted in detail, but the capability is included to allow the program user to study the degree to which they might explain cost penalties not otherwise identified. One way to do this is to specify a fluctuation in production rate (see below) which declines over time or unit output.

Parameters to control the cost effect of changes in production rate must also be provided. Note that the desired rate is already established by the schedule and limitations are provided by manpower constraints and interdepartment relationships. Either a linear or exponential model will be permitted. The former has some advantage in that it can be more easily related to organization and facility characteristics. In any case, some allowance is needed for the inefficiency created by the change process itself.

Task changes are involved in the startup process, as discussed above. But we must also consider how continuing progress affects future unit cost. In addition, major design changes may be anticipated, which must be examined carefully to avoid overlooking one or more of their complex ramifications. Such computations again require considering the phaseout, retooling and startup requirements, just as for a production interruption, together with the penalties due to rework, retrofit and interference between work-centers and departments.

Phaseout requires decisions on the impact of factors such as production rate, greater turnover as the end of the production run approaches, a slowdown in the rate of progress, and so on.

Further Considerations. An important source of cost is the compounding effect generated by the overlap of design and production startup. While this especially affects new product introduction, similar effects also occur at other times. Some of these costs are already provided by the allowances for rework, training and low production rates. However, it is usually necessary to make further provision using calculations based on the various types of excess cost being generated.

An index of departmental "morale" can also be provided which can modify both basic efficiency and personnel turnover rates. It is constructed by the program to fit user requirements, reflecting such considerations as production rate, number of units remaining to produce, the degree to which basic costs are subject to compounding, etc. It can also be set to collate with arbitrary values of time or

cumulative output. In similar manner, an index of management and procedures efficiency can be provided to help quantify the effects on support services of other causal factors, and conversely.

Conclusion. Development of this program is now in process, and a preliminary version should be in operation by mid-1980. Another six months will then be needed to incorporate some of the more significant features. Only then can the process of learning how to use this new tool really get under way.

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(6) Appendix items [9] and [15].
(7) Appendix item [10 (1)].
(8) Appendix item [10 (4)].
(9) Appendix item [10 (5)].
(10) Appendix item [10 (1)], pp. 207-208.
(11) Appendix item [42].
(12) Appendix item [11].
(13) Appendix item [17].
(14) Appendix item [10 (5)], pp. 381-383.
(15) Appendix items [34] and [5] respectively.
(16) Appendix item [8].
(17) Appendix items [14], [16] and [46].
(18) Appendix item [10], page 48.

APPENDIX

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(3) "The Cost Effect of Design Changes," pp. 285-329. C
(4) "The Cost Effect of Manpower Changes," pp. 333-363. F
(5) "The Cost Effect of Other Production Disruptions," pp. 367-409. D
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Note: (1)

A - New Product Introduction and Startup		18
B - Production Rate Changes		10
C - Design Changes		10
D - Production Interruptions		14
E - Product Phaseout		8
F - Manpower Changes		5
G - General Disruption		6
P - Progress		1
R - Rate of Learning		2
X - Other		3
	Total	77

AN EMPIRICAL ANALYSIS OF THE RELATIONSHIP BETWEEN COST, COST ESTIMATION, AND COST ANALYSIS

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ABSTRACT

Most observers agree that our national economy has its problems; recent trends characterized by high inflation, high interest rates, and depressed economic activity all support this reported condition. Further, reduced federal funding, on a relative basis, is another characteristic of our economy. Therefore, efficient and effective use of defense funds is and will continue to be a major issue to acquisition and contracting managers. Contracting and acquisition personnel in the DOD need to improve their understanding of the concept of cost, cost estimation, and the role of cost analysis in the acquisition and contracting environments. This paper will survey several research studies and reports that focus on cost, cost estimation, and cost analysis as they apply to the Government and industry and their interface as buyers and sellers. Research results will be considered and final conclusions provided as to the efficacy of these concepts of cost, cost estimation, and cost analysis.

INTRODUCTION

Most observers agree that our national economy has its problems; recent trends characterized by high inflation, high interest rates, and depressed economic activity all support this reported condition. Further, reduced federal funding, in constant dollars, is another characteristic of our economy. Reduction of federal funding will probably continue on a relative basis, especially in the Department of Defense (DOD). Therefore, efficient and effective use of defense funds is and will continue to be a major issue to contracting and acquisition managers. In the context of our economic condition, the international situation demands a defense budget that will keep the United States militarily strong for the foreseeable future. To meet this demand, contracting and acquisition personnel in the DOD need to improve their understanding of the concept of cost, cost estimation, and the role of cost analysis in the contracting and acquisition environments.

This paper will survey several research studies that focus on cost, cost estimation, and cost analysis as they apply to the Government and industry and their interface as buyers and sellers.

COST

"Cost" is a multi-faceted term which can have different meanings depending on specific frames of reference. Basically, costs can be partitioned initially into historical and future costs. This distinction is based on the two primary uses of cost by accountants and economists.(1) Historical costs are symbolic of resources which have been consumed by some process or activity. They are recorded so that input and output efficiency can be measured in terms of the accomplishment of specific organizational objectives. Future costs are economic in nature in terms of the opportunity costs that are associated with alternative courses of action which are related to management decision making.

The most significant aspect of cost then is the problem of cost definition. Several different types of cost are listed in Table 1. This listing is partial as the various combinations of the word "cost" with a modifier is almost endless. Thus, it can be seen that the term has significance only when associated with a modifier or specific frame of reference.(2) From the perspective of the contracting and acquisition community, decisions for program funding deal with future costs, using historical costs as a reference point or datum.(3)

Table 1. Types of Cost

Discipline	Functional	Frequency of Occurrence	Decision Choice
Economic	Accounting	Recurring	Opportunity
Social	Economic	Current-Year	Alternative
Political	Engineering	Next-Year	Incremental
Accounting	Procurement	Monthly	Marginal
	Maintenance	Annual	Relevant
	Production		Additional
	Factory		Differential
	Manufacturing		Avoidable
	Distribution		Out-of-Pocket
	R&D		Replacement
	Finance		Imputed
	Administration		
	Marketing		

Behavior	Time	Location	Descriptive
Fixed	Sunk	Internal	Labor
Variable	Historical	External	Material
Semi-Variable	Past	Direct	Overhead
Marginal	Future	Indirect	Personnel
Total	Experiential	Average	Operating
Average	Expired	Total	Manpower
Joint			Construction
Common			Design
Controllable			Real
			Actual
			Unique
			Common
			Joint
			Prime
			Conversion
			Budgeted

A longitudinal study of the term "cost" disclosed that mutually exclusive partitioned subsets cannot be developed.(4) After several partitions the delineation breaks down and overlaps occur. One attempt at such a partitioning is illustrated in Figure 1.

postulated by Glover in terms of a cost definitional model.(5)

In constructing a taxonomy of cost terms, Glover uses a logical approach to categorizing these terms by borrowing basic concepts from logic and

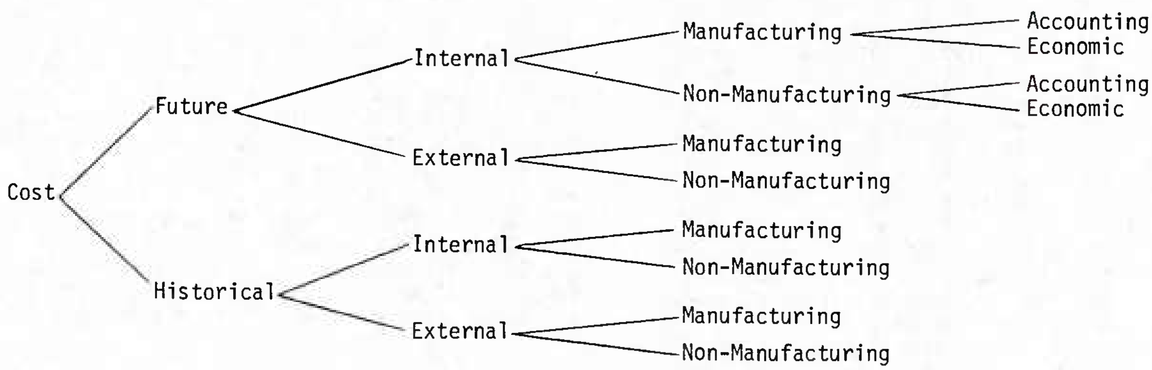

Figure 1. Cost Taxonomy

As can be seen after several iterations, the mutual exclusivity requirement is violated in that for some the concept of future and economic costs are somewhat synonomous. Thus, in terms of communication and dealing with the cost variable, it is important to determine initially what cost the parties are dealing with in a given case. One conceptual approach to this problem has been

mathematics and uses them to build a model for putting cost terms into different categories. This concept involves a mapping or transformation of sets. A "use" transformation is used to associate cost terms with a specific frame of reference. Two basic assumptions of the model are: first, that cost has the potential to be measured in monetary terms; and second, that cost is usually the result of a decisio

The domain of the "use" transformation (U) is the set of all possible cost terms or types of cost (T), and its image is a specific frame of reference (z). The model is illustrated in Figure 2.

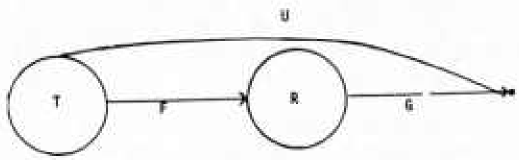

Figure 2. Cost Transformation Model

In the above illustration, given k cost terms, F associates these terms with possible frames of reference in R. G then further limits the number of possible frames of reference to a specific frame of reference in time (z). R is a general set of possible frames of reference applicable to a given situation, but has not yet been limited by time. The cost terms associated with these frames of reference are general terms that can possibly be estimated, but not measured. After time is applied by transform G, then a frame of reference becomes specific and the categories of cost are known. These categories are: actual cost and non-actual costs, social, estimated, and opportunity costs. All other costs terms can be associated with these terms depending on the specific frame of reference.

A generalized defintion for cost was formulated from these studies.(6) It is as follows: From a generic standpoint cost may be defined as "a multiple-faceted term which has meaning only when associated with a specific frame of reference. Actual cost (accrued and disbursed) generally involves the payment for a product and/or service, (includes both barter and monetary transactions). The term relates to the supply segment of the market. Exceptions to actual cost which must be considered are "social, opportunity, and estimated costs."

This definition specifically ties meaning to the frame of reference and highlights the fact that actual costs are historical in nature and relate to the supply or industrial side of the market. The basic definition is an accounting one which forms the basis for the initial approach to cost. To add the managerial dimensions which relate to decision making for the future, the economic concept is highlighted. This conceptual definition provides a foundation for an examination of the process of cost estimation.

COST ESTIMATION

The cost estimation process involves structures, other processes and people. It is a process constrained by its very nature, by its environment, and by the people who conduct the process. As with the term "cost," a cost estimate is future oriented. It is an integral part of the organizational planning process. From a definitional standpoint, a cost estimate is at best a reasoned guess about a future cost outcome. A cost estimate is based on historical cost tempered with expectations as to future events.

Several characteristics of a cost estimate are germane. As explained, it is a prediction relative to a future cost event. It involves a continuous variable, cost, which is expressed in dollars that are measured in relatively discrete units. The estimate requires judgment in its formulation and is therefore subjective in nature. This fact means that two experienced estimators will probably come up with different numbers using the same techniques and data base, the difference being the risk propensities of the individuals. Some individuals are more risk averse and therefore usually build a larger contingency provision into the estimate to avoid being wrong. On the other hand, more liberal risk "takers" may attempt to be more precise with estimates. Also, cost estimates are made in an atmosphere of partial information. Even with an excellent data base or cost history for a variable, the future is still uncertain and cost estimates are probabilistic in nature. Finally, a cost estimate emanates from a specific point in time and is only valid so long as the assumptions which structured its magnitude remain acceptable. As time passes, additional information is received which, if monitored properly, can permit the adjustment or revision of estimates.

This need to revise estimates is in consideration of the uncertainty which exists and which must be acknowledged when estimates are being formulated. A simplified uncertainty spectrum is illustrated in Figure 3. The key to uncertainty analysis is information.(7) The relationship is

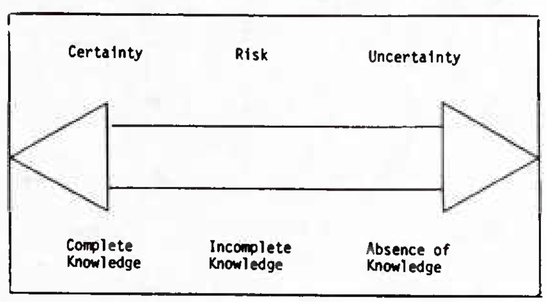

Figure 3. The Uncertainty Spectrum

inverse. As additional information is received, the uncertainty level is reduced. This information may be obtained from various types of management information systems.(8) The unwillingness to revise estimates in view of new information is one of the most common mistakes that managers make as they deal with estimates. For some reason the estimate assumes an aura of certainty and it is anticipated that the final cost outcome will be the same as the estimate. This approach ignores the very nature of the process. Another fallacy is to not structure estimates in probabilistic terms by developing a confidence interval and clearly stipulating that the final outcome is more likely to be in a certain range of values, rather than a point estimate. These characteristics of cost estimates impact on the techniques which are used for cost estimation. Five basic cost estimation techniques have been identified. Many variations exist, however, they can be classified as one of these five or some combination of them. They are: expert opinion; catalog price comparison, etc.; analogy, industrial engineering method, and statistical.(9) Probably all of the techniques have their place at one time or the other. Four of these techniques will be discussed.

In the case of expert opinion, an experienced individual is tasked to develop an estimate of future cost for a given variable or set of variables. The estimates are developed based on historical experience and tempered with expectations about the future. The process is very subjective and subject to a high degree of inaccuracy.(10)

The analogy technique is also judgmental. The analyst starts with a system or product with which they are familiar. The current product which is under consideration is compared with the past, similar product. The estimate is then formulated using the cost for the old product as a baseline. The differences between the products are then costed out and this delta is added to the initial estimate to arrive at the final cost estimate.

The industrial engineering method is based on the use of the drawings for the product. (11) Costs are estimated at a low level of detail and then aggregated to develop a total. There exists considerable opportunity for error at the detailed level and then the aggregation of these errors based on the risk propensities of the estimators.

The statistical approach involves the identification of physical performance characteristics which are considered to be cost drivers. The assumption for the estimate, using the identified relationships (often referred to as CERS - "Cost Estimating Relationships") is that the new product is not significantly different from the old, therefore, it is acceptable to project the costs of the old product into the future to serve as the estimate for the new product. This technique is based on the use of regression analysis and is often referred to as a "tops down" approach as contrasted with the industrial engineering method which is termed a "bottoms up" approach.

These techniques have not been discussed in great detail as that is not the purpose of this paper. Individuals needing detailed methodological information are referred to any of the references quoted above.

ENVIRONMENT FOR COST ESTIMATION

Cost estimation takes place in the weapons systems acquisition process environment. This process is diagrammed in Figure 4.

PHASE	PRE CONCEPTUAL	CONCEPTUAL	VALIDATION	FULL SCALE DEVELOPMENT	PRODUCTION	DEPLOYMENT	REUTILIZATION & DISPOSITION
COST ESTIMATING TECHNIQUE	1, 2, 4	2, 4	2, 4	2, 3, 4	3	3	3

KEY: 1 = Expert Opinion 2 = Analogy 3 = Industrial Engineering 4 = Statistical

Figure 4. The Weapons Acquisition Process

As can be seen from Figure 4, in the early phases of the weapons acquisition process, there is a high level of uncertainty. The specifications for the system may be rather vague. In this situation, the statistical, analogy, and expert opinion techniques can give reliable enough estimates. As the system moves through the process over time, technical, schedule, and cost uncertainties are reduced based on the receipt of information from testing and evaluation. Finally, in the full-scale development and the production phases, the industrial engineering approach with detail and precision can be used. Many mistakes and errors are caused by an estimator using the improper technique during the wrong phase without qualifying or limiting the application of the resulting cost estimates. The activation of the weapon system acquisition process is effected through the contracting process.

The contracting process is comprised of three phases, pre-award, award, and post-award. This process is illustrated in Figure 5. The type of cost estimation technique applicable to the contracting process is determined by the related weapons system acquisition phase. For example, if the contract to be placed is for research and development in the conceptual phase, the best technique might well be statistical whereas if it is related to the production phase, the industrial engineering approach would be more relevant. The annotations in Figure 5 illustrate the relationship between cost, cost estimation, and cost analysis. In the context of the weapons systems acquisition and the contracting process, cost estimates are available in four basic formats: Cost Analysis Improvement Group (CAIG) estimates; Independent Cost Estimates (ICE); estimates made by personnel assigned to the System Program Office (SPO), and finally estimates made by the private firm seeking the program.(12) It is obvious that each have their own vested interests which affects their objectivity in terms of developing and using cost estimates. Specifically, in the requirement cycle, the emphasis is on cost estimation by the requirements staff. In the solicitation cycle we have cost estimation by industry. The government's responsibility at this point is to develop an independent cost estimate of what the program ought to cost, plus perform an uncertainty and cost/price analysis. After contract award the emphasis shifts to cost control on the part of both industry and government. The government's role is normally cost surveillance and for industry the use of standard cost accounting or other cost techniques to effect cost control.

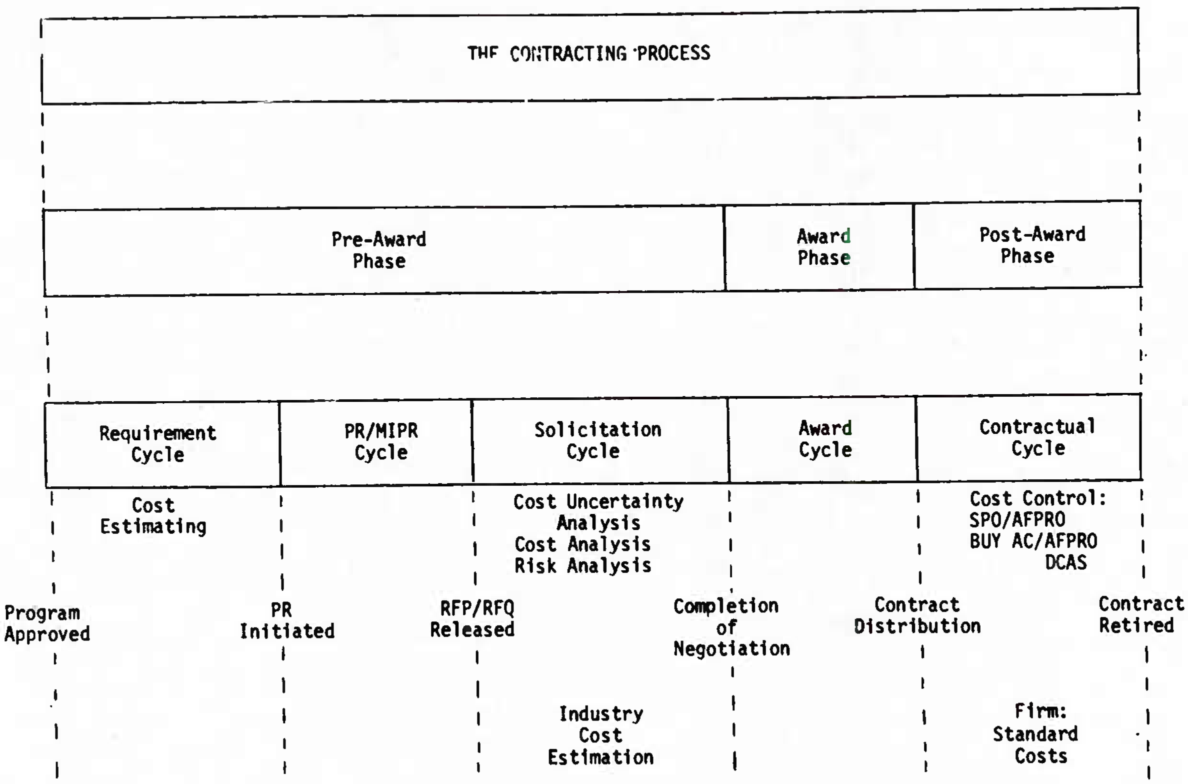

Figure 5. The Contracting Process

Erickson examined the role of cost estimation in the acquisition of aircraft by the DOD. His basic conclusion is that the basic estimating system is better than generally accepted.(13) His research disclosed that the DOD components were using sophisticated and up-to-date methodologies for cost estimating which resulted in quite accurate estimates. The complicating factor which led to low estimates and in many cases, cost overruns was "cost optimism." The deliberate use of low estimates in order to get a program funded.(14) After the program is in development, the specific service can go to Congress for additional funding to cover the "cost growth." The private sector has a similar motivation to lower estimates and "buy in" on programs. A study of the Air Force estimating process by Lewis and Pearson found similar conditions. The conclusions were that program advocates develop cost estimates in the most optimistic manner in order to sell the program at each decision point.(15)

In this same study, the researchers found that the different Air Force activities used basically the same techniques for cost estimating.(16) However, they encountered a semantic problem in that the techniques were called by different names by different groups. Also there was some confusion as to what constituted an accurate estimate--the term "accuracy" not being defined by policy makers. Another problem which surfaced was inadequate data bases used for estimating purposes.

In a study by Yanke and Mullineaux of the estimation process for jet engines in the early phases of the weapon system acquisition process, they found that the statistical techniques were the most useful when a paucity of detailed data exists.(17) They concluded that existing statistical models do not adequately deal with the uncertainty inherent in cost estimates and propose that the statistical model used should be developed with an eye to the degree of certainty that the model is required to maintain. This research supports the authors' thesis in Figure 4 that the statistical estimating approach is applicable in the conceptual and validation phases.

In a study by Nelson and Smith, the Yanke and Mullineaux conclusions were supported.(18) They conclude that many statistical cost models in the DOD "are not well constructed, based on partial or erroneous information, are not well documented, or a combination of these deficiencies." Their study examined the process of developing cost estimation models and the characteristics of some and is a very useful reference for those individuals seeking a taxonomic approach to cost estimation models.(19) Thus it can be seen that the research on cost estimation is basically supportive of the techniques and tools in use by practitioners. Accepting this conclusion sets the stage for an evaluation of the process of cost analysis used by contracting personnel.

COST AND PRICE ANALYSIS

The role of price and/or cost analysis is a function of the contracting methodology envisioned by the government. For the advertised methodology it is assumed that the competitive market is involved. If collusion is not present, it is assumed that the market place will, through competition, result in a fair and reasonable price. This type of methodology is used for goods and services which are standard and fairly homogeneous. The concepts of price and cost analysis normally can be used in evaluating the bids in terms of responsiveness to the solicitation. Price analysis involves a comparison of aggregate program or unit prices with past programs, catalog prices, or other standard price sources. It is often used by itself or with cost analysis. With this understanding, the remainder of this discussion will deal with cost analysis. Department of Defense regulations require some form of price or cost analysis with every negotiated contract. The objective being to assure that the prices quoted are fair and reasonable. Cost analysis is a detailed process of evaluating each cost element in the light of past experience, auditor recommendations, and existing market conditions. The basic assumption of the process is that the contractor knows how to cost out the program and that the government can evaluate this proposed cost and determine whether or not it is fair and reasonable (a term itself not understood unless evaluated in an economic context). Constantin stipulates, based on his research, that few contractors or firms know other than total costs especially from a functional cost perspective.(20) So at times, cost analysis is probably conducted on "guesstimates" and the outcome is a cost growth.

The focus of cost analysis is the contracting process outlined in Figure 5. The cost analysis process begins with a contractor's cost proposal in the traditional sense. Actually, this is fallacy in that the contracting staff should develop their own independent cost (ICE) estimate for the program based on past and similar products. This ICE then will serve as a baseline for the evaluation of the contractor's cost proposal. Erickson indicates that the reconciliation of the differences between these two estimates is the most critical issue facing the contracting community.(21) The Air Force approach with definitions, cost analysis techniques, etc., are detailed in ASPM No. 1 and will not be repeated in this paper, rather some research issues will be considered.(22)

The application of cost analysis to the contracting process has not been researched in detail. Probably the most noteworthy effort was a study conducted by the Air Force .(23) The purpose of the study was to Improve Modern Pricing and Costing Techniques (COPPER IMPACT). The initial approach was to survey the existing Air Force organization, techniques, and staffing for pricing. Once this survey was completed, the goal was to develop new techniques to use in the cost analysis area and to train personnel in their use. This is a simplistic discussion of COPPER IMPACT but meets the needs of this paper. The significant point is that a plan was developed to improve modern pricing and costing techniques. Several projects were initiated under COPPER IMPACT and resulted in techniques for field use. These techniques include PIECOST (Probability of Incurring Estimated Cost), SHOULD COST, and POESMIC (Program Office for Evaluation and Structuring Multiple Incentive Contracts). A study by Schaefer and Birkhead examined the use of SHOULD COST on several programs .(24) In the study, prices which were negotiated based on SHOULD COST were compared with prices based on conventional cost analysis. The conclusion was that the SHOULD COST techniques did not result in the negotiation of significantly different prices than those arrived at using cost analysis. While not the final word on the use of SHOULD COST, it is an interesting study which indicates that pricing techniques for cost analysis are not panaceas, rather each has its uses and limitations. Studies need to be conducted of what caused the Air Force to modify PIECOST and to basically eliminate the POESMIC office.

SUMMARY

Cost is a multi-faceted term which can have different meanings based on specific context. In dealing with cost as a variable, the initial concern is a definitional one. All parties to that situation must agree on a specific meaning for cost based on a stipulated frame of reference. This will facilitate communications and interaction. Cost estimation is more art than science, however, several techniques such as the expert opinon, analogy, statistical and industrial engineering approaches have their advantages. In the context of the weapons systems acquisition process, the statistical approach is useful in the conceptual and validation phases whereas the industrial engineering approach is more suited to the full-scale development and production phases. Cost analysis is an evaluation of the cost estimates developed during the different phases and the approach used for developing the estimate must be considered. There is a need for research in the cost analysis area to determine the efficiency and effectivess of the process.

Thus, the relationships between cost, cost estimation, and cost analysis is an interdependent one. In the final analysis, cost analysis is a process of reconciling cost differences and developing an estimate of expected cost which has been derived using rigorous technical methodologies, tempered by judgment, which are clearly understood by the parties involved.

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TRACKED VEHICLE RESOURCE ANALYSIS AND DISPLAY (TREAD) COST MODEL

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ABSTRACT

A computerized life cycle cost model (TREAD) has been developed that is suitable for estimating the life cycle cost of advanced technology armored combat vehicle concepts as well as current inventory tanks. The TREAD cost model is broken down into four parametric submodels: a production or hardware manufacturing submodel, an investment submodel that captures other elements of investment cost, an operating and support (O&S) submodel, and a research and development (R&D) submodel. Each submodel consists of the cost elements outlined in the Department of the Army Pamphlets 11-2, 11-3, and 11-4 (R&D, investment, and O&S guides for Army materiel systems). The input requirements are simple and the output format is flexible.

INTRODUCTION

A computerized life cycle cost model has been designed for estimating the life cycle cost of advanced technology armored combat vehicle concepts as well as current inventory tanks. The work was performed under the sponsorship of the Defense Advanced Research Projects Agency (DARPA).

DARPA, the Army, and the Marine Corps are involved in a joint effort called the Armored Combat Vehicle Technology (ACVT) program. The purpose of this program is to examine characteristics and developments of new armored vehicle designs in order to define the next generation of combat vehicles. To this end, a high mobility/agility (HIMAG) test bed vehicle has been built that incorporates features of variable weight, horsepower, suspension stiffness, fire control system, and a 75-mm rapid fire automatic cannon. In addition, as part of the ACVT program, a lightweight, high survivability test vehicle (HSTV-L) had been built as a test bed to study the value of antiarmor systems in the 15- to 21-ton weight range. The military value of these armored vehicle concepts is being evaluated by extensive testing and analysis programs. The selection of preferred armored vehicle concepts for future generation vehicles requires that credible estimates of system costs be considered along with effectiveness.

SCOPE

Cost estimates for materiel systems are derived by one of two methods: through either the "bottoms-up" approach from detailed, industrial engineering calculations, which historically have been employed by defense contractors in proposal pricing and planning purpose estimates for the Government; or by the "top-down", or parametric, approach, which is based on relationships between system cost and physical or performance characteristics of the system (or subsystems). The TREAD cost model is based on the parametric approach, since, during the early phases of the acquisition process, the system concept designer is not likely to have the detailed information (such as the cost of major pieces and man-hours for assembly) that is necessary for the "bottoms-up" method. Hence, the parametric method, based on relatively top-level system physical and performance characteristics, is appropriate for estimating systems costs of the conceptual vehicles generated through the ACVT testing program.

In many parametric cost models, cost estimating relationships (CERs) are derived from cost histories of prior programs. Unfortunately, for armored combat vehicles, there is a woeful lack of data for many subsystem cost categories. For example, in some cases, the entire vehicle was purchased under a fixed-price contract, and the Government was unable to obtain information needed to identify the hardware manufacturing cost of even the main parts of the vehicle. In other cases, historical records had been destroyed or lost. The ability to estimate maintenance costs was seriously hampered by the lack of a suitable data base for deriving historical estimates of the hours or miles between failure of major items and the actual man-hours spent on repairs in the field. Similarly, the development phase was especially difficult because of the lack of an adequate tracked vehicle data base. Finally, one of the basic purposes of the model was to estimate costs of the advanced technology components, and there was no historical experience upon which to base estimates for these components. Thus, for a substantial fraction of the cost categories, where historical data were sparse or nonexistent, or advanced technology components were involved, CERs were synthesized based on appropriate analogs and engineering judgment, aided by advice from Government and defense contractor experts. The Appendix contains a list of Government offices and defense contractors that contributed to this effort.

The predictive capability of any cost model should be viewed cautiously. There are large variables that affect the actual cost of a system that are

unrelated to vehicle or program characteristics. Future wage agreements, strikes, shortage of materials, program management, the actual distribution of contractor overhead costs between the system being estimated and other programs, and technological breakthroughs are examples of unpredictable factors that affect hardware development and manufacturing costs. The relationship of future military pay scales to predicted inflation factors, Service-derived Tables of Organization and Equipment (TOEs), and the amount of training ammunition to be expended annually in the future are examples of variables that could profoundly affect operating and support (O&S) costs and, hence, life cycle costs. Therefore, the TREAD model cannot claim to predict absolute costs with great accuracy, but it can produce good relative cost estimates between competing systems.

APPROACH AND METHODOLOGY

The total life cycle TREAD cost model consists of four submodels: A production or hardware manufacturing submodel, an investment submodel that captures other elements of investment, an O&S submodel, and a research and development (R&D) submodel. Figure 1 indicates the information flow in the TREAD model. The production submodel was developed first, since the costs of many of the elements of the other submodels are closely related to the hardware manufacturing cost.

TREAD COST MODEL

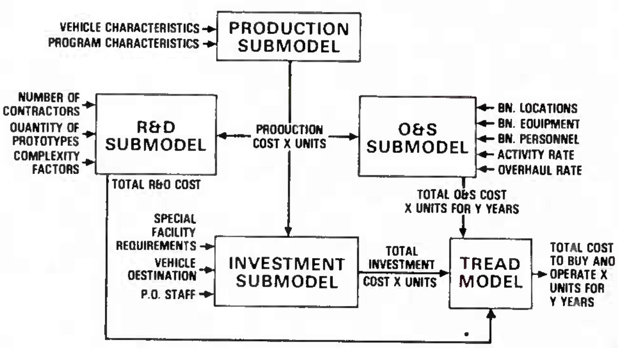

Figure 1

In the past, many models have estimated hardware cost by combining several subsystems using vehicle weight as the driving variable. This method is much too crude, particularly in estimating costs of advanced technology components. The approach used for the TREAD hardware manufacturing submodel was to break down the vehicle system into its subsystems and occasionally into components of subsystems; collect historical cost data or, where such data were unavailable, gather cost estimates by consulting with Government and defense contractor experts; estimate cost driving variables based on physical or performance characteristics; formulate CERs; program these relationships into a computerized model; and, finally, iteratively test, validate, and revise the submodel aided by suggestions from industry and Government experts. The vehicle components and the costs captured are those outlined in the Army Life Cycle Cost Matrix and Department of the Army (DA) Pamphlet No. 11-3, Investment Cost Guide for Army Materiel Systems, April 1976. In the case of the fire control system, no suitable physical or performance characteristic could be found to develop an all-encompassing CER; instead, a fire control cost matrix is presented from which a concepts designer can select fire control components to provide the desired capability (which can vary from that of rudimentary visual, manual systems to relatively complex, closed-loop systems).

The investment submodel was designed to capture the investment cost elements in DA Pamphlet 11-3 that are not included in production. Using historical data and expert advice, the cost of most elements was estimated as a percentage of the average unit vehicle manufacturing cost.

The O&S submodel includes the cost elements specified in DA Pamphlet No. 11-4, Operating and Support Guide for Army Materiel Systems, April 1976. As mentioned above, there was no suitable data base for estimating man-hours required to repair equipment in the field. Therefore, a somewhat less refined approach was taken to estimate maintenance manpower costs; military maintenance personnel were estimated by counting maintenance personnel according to occupational specialty and grade/rate in the battalion (using current Tables of Organization) plus those in direct and general support who are directly employed in maintaining the tank system. CERs were formulated based on historical data detailing the costs of replenishment spare parts and depot overhaul. Most of the other cost elements in DA Pamphlet 11-4 were accounted for by cost factors derived from the Army Force Planning Cost Handbook.

The framework for the R&D cost submodel consists of the cost elements included in DA Pamphlet No. 11-2, Research and Development Cost Guide for Army Materiel Systems, May 1976. The submodel was broken down into two distinct phases, Validation and Full Scale Engineering Development, each of which was treated separately. An analog approach was employed to estimate development engineering costs; the contractor prototype manufacturing cost was related to the vehicle manufacturing cost that was derived from the production submodel. Estimates for the remaining cost elements were developed using factors based on XM1 and other systems that related these elements to the principal endogenous variables, contractor development engineering cost, and contractor prototype manufacturing cost.

The model was designed requiring the user to provide a minimum of inputs to make the model reflect as accurate an estimate of tank costs as possible. In developing CERs, driving variables were selected that the concepts designer would be likely to have ready knowledge of, although the resulting statistical correlation might be somewhat poorer than one derived from the use of

more esoteric driving variables. Table 1 is a summary of the inputs required to run the model.

Table 1. Model Inputs

Cost Element	Input Requirements
Production:	Number of Units and Production Rate
• Hull	Armor type and weight
• Turret	Armor type and weight
• Suspension	Wheel loading and type
• Power Package	
- Engine	Type and HP
- Transmission	Engine HP
• Fire control	Characteristics of tracking system
• Armament	
- Primary weapon	Projectile weight and rate of fire
- Automatic feeder	Round weight and rate of fire
- Secondary weapons	Type and caliber
• Ammunition	Round diameter, number and type of rounds in initial buy
• Communications	Type and number of radios
Other Investment:	
• Nonrecurring investment	Existing or new manufacturing facility
• Project management	Number of people, years in existence
• Transportation	Number, weight, cubage, destination
Operating and Support:	Number of Tanks in CONUS and Europe Fraction of Tanks in Operational Units Years in Active Inventory
• Military personnel	Battalion TO&E
• Consumption	
- Parts, POL	Activity rate (mi/yr)
- Ammunition	Type and number of rounds fired per tank per year
• Depot maintenance	Overhaul cycle (miles or years)

Table 1. (continued)

Research and Development:	
• Development engineering	Number of contractors by phase* Adjustment factors by phase*
• Prototype manufacturing	Number of prototypes by phase*
• Facilities	Thruput by phase*

* Validation and full scale engineering development.

Figures 2 through 5 illustrate some selected cost estimating relationships. Figure 2 shows the CER for the hardware cost of aluminum hull and turret structures. There are other CERs for hulls and turrets made of rolled homogenous steel armor, cast steel armor, and special armor.

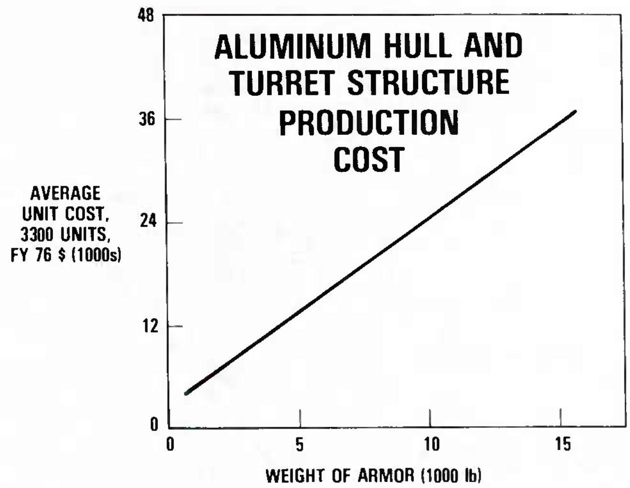

Figure 2

Figure 3 illustrates the CERs for the manufacturing cost of other hull and turret components. The cost of the hull components consists of the cost of such items as ammunition racks, grilles, hatches, and access doors, and their integration and assembly into the hull. The turret components costs are made up of the turret bearing, hatches, ammunition racks, and weapons mounts, and their integration and assembly.

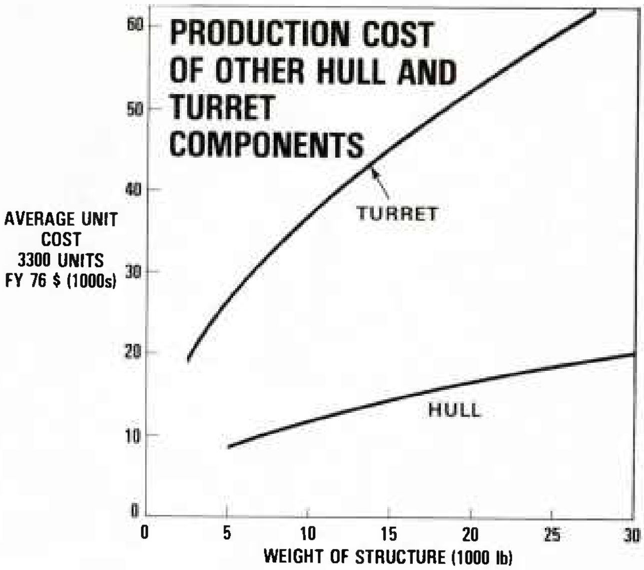

Figure 3

Figure 4 depicts the CER for the hardware cost for two types of suspension systems. The costs cover the spring and damping systems, roadwheels and arms, sprocket assembly, support rollers, and track, and their integration and assembly into a complete suspension system.

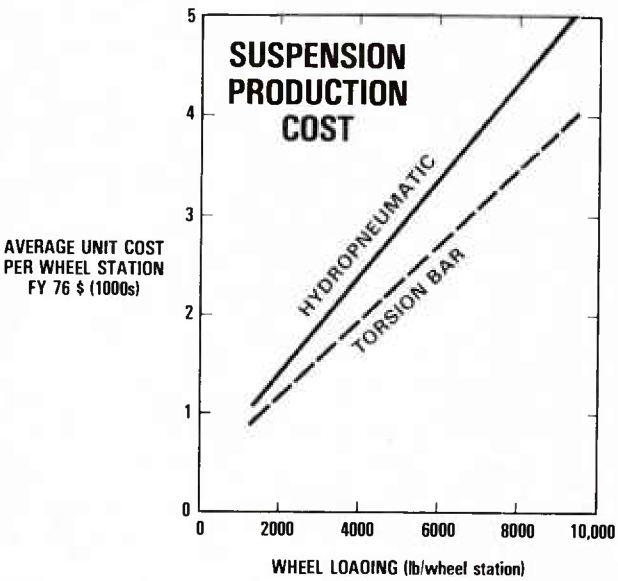

Figure 4

Figure 5 is illustrative of a CER used in the O&S submodel. It shows the cost of overhaul of a complete vehicle.

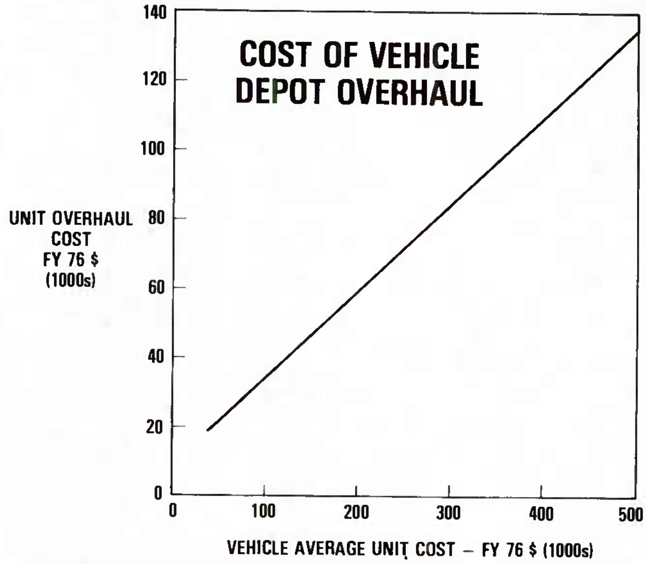

Figure 5

The model output format is flexible and can provide cost estimates for a total force, battalion, or a single tank either for life or per year. The model documentation was designed to facilitate changes in the computerized model when new or refined data become available or as desirable changes in methodology become apparent. The TREAD cost model is being improved continually, particularly by the addition of CERs for advanced technology equipments (e.g., rotary engines).

MODEL VALIDATION

Cost estimates provided by TREAD have been compared with estimates from other sources for the XM1 tank and the Infantry Fighting Vehicle (IFV)/Cavalry Fighting Vehicle (CFV). The TREAD model estimates the manufacturing cost and 20-year life cycle cost of the XM1 at about 3 percent less than the cost estimates by the XM1 Program Manager's Office, and at approximately 8 percent more than the estimates prepared for the Independent Parametric Cost Estimate published by the Office of Comptroller of the Army. The TREAD estimate for the hardware cost of the IFV/CFV is about 8 percent higher than the estimate for these vehicles by the Fighting Vehicle Systems Program Manager's Office.

CURRENT USE OF TREAD

The ACVT Study, being conducted under the aegis of the U.S. Army Armor and Engineer Board with widespread Army and Marine Corps participation, is using the computerized TREAD model to provide relative cost estimates for conceptual vehicles and concepts of operations. Hardware costs have been estimated for 25 conceptual vehicles designed by the Tank-Automotive Research and Development Command. These costs are being used in conjunction with effectiveness estimates to eliminate certain configurations from further consideration.

Life cycle cost estimates are being prepared for those vehicles that survive the initial evaluation.

APPENDIX

GOVERNMENT OFFICES AND DEFENSE CONTRACTORS CONSULTED IN THE DEVELOPMENT OF THE TREAD COST MODEL

Government Offices

U.S. Army Tank-Automotive Materiel Readiness Command
U.S. Army Tank-Automotive Research and Development Command
U.S. Army Materiel Development and Readiness Command
U.S. Army Armaments Readiness Command
U.S. Army Armaments Research and Development Command
U.S. Army Test and Evaluation Command
U.S. Army Operational Test and Evaluation Agency
U.S. Army Depot Systems Command
Office of the Comptroller of the Army
Project Manager's Office, XM1 Tank System
Project Manager's Office, M60 Tank Production
Program Manager's Office, Fighting Vehicle Systems
Office of the Secretary of Defense, Cost and Economic Analysis

Defense Contractors

Institute for Defense Analyses
Logistics Management Institute
General Motors
National Water Lift
AAI
ARES
Delco Electronics
Hughes Aircraft
Teledyne Continental
Pratt Whitney
Rolls Royce
Caterpillar
Garrett
Food Machinery Corporation
General Research Corporation
Allison
Sundstrand
General Electric
Chrysler Corporation
Curtiss-Wright

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Al Berman, OMB
Budget Examiner - National Security

"Originality is only undetected plagarism".
- Robert Judson

MEASUREMENT OF AVIONICS CONTRACT RESEARCH AND DEVELOPMENT REQUIREMENTS AND THEIR GROWTH

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ABSTRACT

Weapon system cost management is one of the most pervasive and challenging problems faced by an acquisition manager. Not only do high and increasing costs of technically complex weapon system programs confront acquisition program managers when planning programs, but subsequent cost growth during the program hinders a manager's ability to maintain control. Although the cost growth problem has been studied by many, findings have been generally limited to describing the extent of the problem or predicting what cost growth might be expected. Little has been done to diagnose the causes of cost growth. If the causes of cost growth could be identified, there is a chance that managers could control cost growth. While this paper does not wrestle with costs directly, it discusses one possible driver of cost growth--the growth of contract requirements on research and development (R&D) programs. This paper, based upon Ronald Blackledge's doctoral dissertation(1) presented and accepted by the University of Texas at Austin, focuses on a methodology used to define, quantify, and measure contract technical requirements for avionics research and development programs.

THE GROWTH OF R&D REQUIREMENTS

The Research. A weapon development project grows from vaguest of uncertainties to the concrete reality of a total system fulfilling national defense needs. Curiously, when anyone discusses requirement growth, he seldom means this inevitable process but rather some unfortunate transfiguration of an initially well-conceived, simple program into a monster. We actually know very little about the orderly growth of requirements in a program--in fact, we don't even know if there are types of requirements common among programs, or if they can be isolated and measured, i.e., counted. Beyond an academic interest in the subject, the understanding of requirement growth can lead to more enlightened control processes during a program's life cycle. The area most affected would be program cost which has a direct conceptual link to man-hours spent (or misspent) on a program.

The dissertation, which forms the basis of this paper, builds on a background of research into cost growth of weapon systems, uncertainty and risk assessment of complex weapon systems, and system requirements and management. Martin Dean Martin(4) developed a cost prediction model for development contracts using uncertainty parameters. He theorized that since uncertainty drives costs, a measure of uncertainty present in a cost estimate could be used to predict potential cost growth. It takes little imagination to relate an uncertainty control process with a requirement definition process. The Defense Science Board 1977 Study Report(5) examined specifications and standards as possible sources of unreasonable costs on defense contracts. This study led to initiatives to increase flexibility and tailoring of specifications and standards as a means to reduce unnecessary costs.(3) Strayer and Lockwood(6) proposed a categorization and classification system, a taxonomy, for system requirements. The argument for such a system is that it can provide a framework from which requirements that conceptually drive costs can be analyzed; costs and benefits from these requirements can be evaluated; risk analysis can be performed; changes to requirements can be assessed; and control of costs can be exercised. The Strayer/Lockwood taxonomy formed the conceptual base of the Blackledge dissertation.

The proposed requirements taxonomy (Figure 1) included six major categories: mission requirements, operational characteristics, design specifications and standards, management specifications and standards, legal obligations, and programming requirements.(6) Mission requirements, operational characteristics, design specifications and standards, and interface requirements were quantified and measured over time (51 months) for seven avionics development programs. These categories were selected to represent the focus of technical control by the program office.

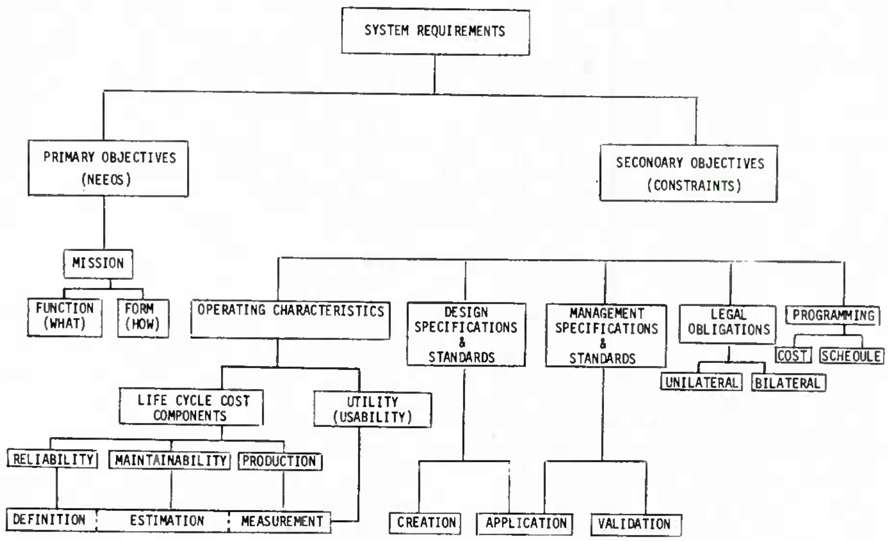

Figure 1. Requirements Taxonomy

The remaining Strayer/Lockwood categories, management specifications and standards, legal obligations, and programming requirements, were omitted from this study.

The hypotheses on the conceptual model were: (a) requirements can be isolated and counted, (b) mission requirements remain relatively stable, (c) operational characteristics exhibit some growth, and (d) design requirements exhibit the most growth.

The focus of the research was that of project offices developing small avionic units for the Air Force. Each of the seven projects selected had gone through the validation phase of its life cycle and had a Part I Critical Item Specification (CI Spec) defining its end product. The requirement taxonomy definitions were operationalized to the CI Spec level, and one program was picked to begin the counting process. Further, the study was limited to requirements under direct government control. It was immediately apparent that requirement sorting (which necessarily precedes counting) would remain a subjective process. Multiple requirements were seen in some paragraphs and even some sentences. The original intent of sentence diagramming to isolate subject (or noun) content collapsed because of multiple requirements in a paragraph, repeated requirements, and descriptive statements tagged to the same requirement.

Instead, an admittedly subjective analysis of paragraph content, based on operational definitions, was undertaken. Specification evaluation, paragraph and sentence at a time, yielded cumulative numbers of requirements by taxonomy type. Analyses were then made of these taxonomy clusters to determine if they were valid, reliable, and meaningful. Once requirement types were isolated for each of a given group of programs, the next step was to surmise that requirement types might have common growth tendencies across programs as reflected in the dissertation hypotheses. As an example, mission requirements embody the basic statement of capability for the project. It would be reasonable to expect minimal additions to a mission requirement would occur in a program's life cycle. In fact, it is the judgment of the authors that any increases in mission requirements are traditionally viewed quite dimly by program managers.

At the other end of the spectrum, the highly detailed "build-to" requirements (Part II Specifications) grow from virtually a zero-base at program beginning to very large numbers at production decision time. This reasoning points to the differential growth patterns posited in the conceptual model hypotheses. Independent relationship of each requirement type with time was believed to be the most valid quantitative approach possible from a statistical viewpoint. This is maintained because of the belief that each requirement type is highly related to other types (thus multicollinearity problems). Under one assumption, all requirement types are seen as defining the same phenomenon and are, therefore, subject to some common external order.

Under quite another assumption, there is a closed system of cause and effect in which mission requirements sit at the top of a hierarchy and design requirements are at the bottom. Under either assumption, high multicollinearity should exist. This effectively precludes meaningful predictions about interrelationships and provides no more meaningful information than that given by each requirement type's variance over time. Of course, if each variable is defined against time, it is implicitly measured against the others.

Findings. The finding concerning requirement type sorting was briefly discussed already. Its inclusion early in this paper marks its critical implications in accepting any finding pertaining to measuring requirements. In order to set the stage for discussion of the findings, a more exhaustive description of the analysis process would be appropriate. Requirements were originally categorized by type for one program. Two subsequent counts on this program were then taken. One set of findings concerns the convergence of counts for each taxonomy type, i.e., how close count one was to count two, and how close count two was to count three. Another set of findings concerns evaluating the final requirement tallies (those in count three for the initial program and all other subsequent program measurements) against their conceptual definitions. Some could quite easily be categorized according to definitions, and some required subjective sorting between requirement categories established by the definitions. This second set of findings, using final requirement counts, should establish how much of a given specification can be accounted for by the Strayer/Lockwood taxonomy.

The convergence between the second and third count of the selected trial project was marked. There was, for each requirement type, on the order of only a 5% difference between the final two counts in a total sample of 400 requirements. When the taxonomy was checked by evaluating the sorted requirements to see if they classically fit definitions assigned to them, the evaluation showed that no better than 75% of any one requirement category could claim that distinction. Clearly this was a disappointment because, even though judgment was subjective, it was one man evaluating his own sorting using his own definitions. However, the 50-75% range held for all requirement types. The correlations of each variable with time were consistent with the hypotheses with the major exception of design requirements which showed virtually no growth in the Part I CI Spec.

Conclusions. The conceptual definitions of requirement types were intuitively persuasive and appeared exhaustive. Further, the reason for difficulty in sorting was seen to be an artifact of the writing process--redundancy, intermixing of requirements, elaborations, etc. The results of the process, when viewed in this light, supported a tentative conclusion that requirements can be sorted--the taxonomy is valid. The alternate hypothesis was, of course, that some other entire taxonomy of some other major requirement type was more appropriate to the data. Overlaps appeared roughly equivalent between each requirement category. This indicates that no major category was missed. Instead, areas of essentially equal ambiguity existed between categories.

The requirements growth with time was consistent with the hypotheses with the exception of design requirements. If one were to assume some exponential growth curve for design requirements instead of a highly sloped straight line, the data would again fit the hypotheses. While this conclusion brings neat closure to the set of fulfilled hypotheses, the findings could not support it in the limited study undertaken. This is probably a failing in not extending the study further into the program life cycle (into the Part II CI Spec) rather than a failing of theory. We are faced with the two facts: (a) design requirements in this study commonly showed a flat slope in Part I CI Specs, and (b) design requirements universally exhibit a small starting number and a tremendous final volume. One either must posit a continuous function akin to exponential growth, or he must assume some major discontinuity. The disparity in numbers between a final Part I CI Spec and the initial Part II CI Spec was immediately suspected, but investigation showed nowhere near the numbers gap to substantiate it. It remains to count the detail requirement growth in Part II CI Specs in order to verify the rapid explosion in numbers.

In conclusion, requirements do seem to cluster around the conceptual taxonomy proposed, and their growth over time appears to be predictable. The evidence is persuasive but not overwhelming.

Implications. It is interesting to surmise that while management does not account for requirements by type, management processes (through time) have implicitly taken them into account. A series of figures will be used to demonstrate this idea.

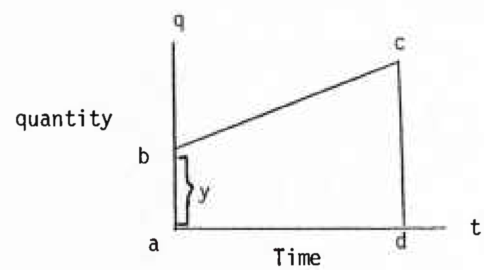

Figure 2. Requirement Growth Over a Program's Life Cycle

A program's life cycle in terms of time is graphed on the t-axis of each figure. The total amount of requirements defining that program at any point in time is graphed on the q-axis. The area under figure abcd (Figure 1) represents total requirements--both defined and controlled by the customer and defined and controlled by the designer--in a program. Note that at time zero, there is a positive amount of requirements, y. This is true if one assumes that a program's life cycle begins in the project office and that it is using some direction from above, such as a Program Management Directive (PMD) or other requirements document. The straight line bc is drawn as the simplest assumption. Considering the hypotheses researched, each requirement type was assumed to grow linearly over time. Thus the aggregate of requirement types would add to a straight line (bc in this figure). While the research proposed that design requirements might actually grow exponentially, this would easily be accommodated by making bc a curve rather than a straight line. For purposes of this example, a straight line will suffice.

Over time, we have invoked different strategies of government control over the requirement growth process. The first strategy is shown in Figure 3.

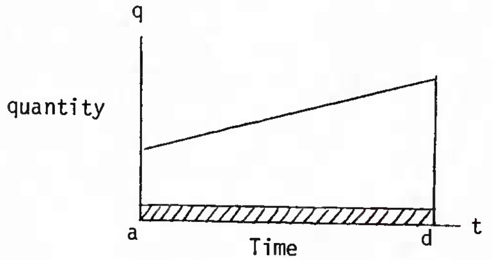

Figure 3. Off-the-Shelf Procurement

The first control exercised over requirement growth was no control--what we today call classic off-the-shelf procurement. In this "take it or leave it" system, you took what was offered or left it. There was no middle ground and no control because there was no development. This was the way George Washington's Army bought cannons, and it is used even today for technical requirements. Socio-economic contract requirements postulate another avenue of study. Line ad (Figure 3) defines the "off-the-shelf" strategy. Figure 4 reflects the next strategy.

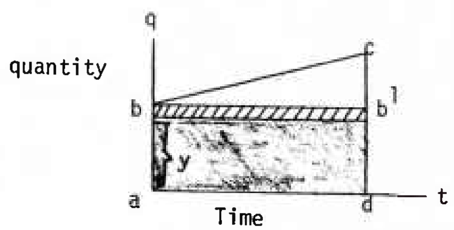

Figure 4. Mission Requirement Control

Procurement of the Wright-Flyer centered around mission requirement control only. We specified that the aircraft would have to fly a closed course at a minimum altitude carrying a pilot and one passenger. Line bb^1 denotes this strategy (Figure 4). The equating of the original y amount of requirements to mission requirements might be a little obscure until one reflects on what a PMD usually contains. While more detailed performance requirements and even some design details and operating characteristic requirements might creep into such documents, their essence is definition of the weapon systems mission. Control under this strategy was inherently resistance to change. The slope of bb^1 was, and remained, relatively flat. This strategy worked in adapting existing systems to government requirements, that adaptation being the bc line. One can argue in case of adaptions that the entire change process was built on a large base of already known requirements--the Wright-Flyer, for instance, was already in existence. Thus, the development process was controlled to insure the existing design (unchanged) met mission requirements. Other changes, on the bc line, were considered unimportant and not controlled.

Figure 5 shows the next type of control.

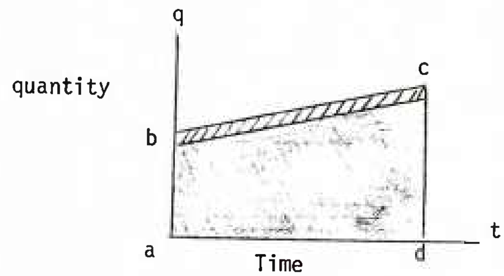

Figure 5. Shipyard Model

This model, the Naval Shipyard Model, was used during World War II. An example is the New York Shipyards and its building of the aircraft carrier "Saratoga." While Henry Kaiser was busy building Liberty ships under contract to the government on the west coast, the Navy chose to totally produce the Saratoga and other warships itself. Unlike the airplane, whose combat brethren evolved from European models, the warship had a long history of American development, mostly under direct Naval control. While not all warships were produced this way, the philosophy engendered is interesting to study. Total control of all requirements is shown in line bc (Figure 5). The true development, of course, didn't occur in the dry docks, but rather with the Naval architects. Their prototype, however, was the final product. Crucial elements in this strategy can be picked out in retrospect: (a) the incremental complexity over previous shipbuilding was not large; (b) the Navy had sufficient designers steeped in Naval architecture and, in fact, more specialized towards warships than private contemporaries; and (c) the strategic war implications of a single capital ship were such that it had to be done right the first time. In essence the 100% control model worked because sufficient expertise resided in-house. This is not necessarily true even in today's Navy.

Figure 6 shows a model consistent with the increased sophistication of management seen in the post-World War II years.

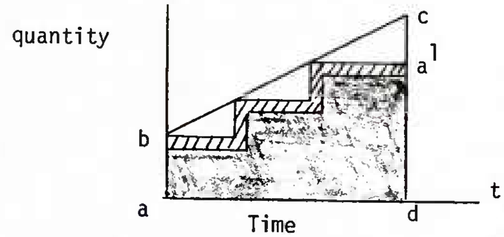

Figure 6. Baseline Model

The baseline model was evidenced in the Air Force 375 series of regulations and manuals in the early 1960's. Up to this time, we have seen the government opt for no control, mission requirement control, and total control in various circumstances. Baseline control reflected block increments of requirement control. The mathematician might reflect that this represents a step-function approximation of total control (Figure 6). As a system is designed, its basic system level performance characteristics were written into a system specification by negotiation between government and contractor.

Once this document was substantially complete, it was placed under formal government control, and the functional baseline was established. No longer would this document be changed with the former degree of ease and flexibility. After the functional baseline was established, the process repeated itself on Part I CI Specs which detail the functions of individual components of the total system. Placing the Part I CI Specs under formal control added a block of requirements to the already controlled system specification requirements. This was called the allocated baseline as system functional requirements were now allocated to lower components. An analogous situation occurred with the Part II CI Specs, and a product baseline was established.

While the system specification and the Part I CI Specs dealt primarily with functions, the Part II CI Specs were called "build-to" specs and incorporated design detail. Functions on a system level sound suspiciously close to mission requirements; functions of components relate to operational characteristics; and design details are synonymous with detail design requirements. While no specification is exclusively devoted to a particular requirement type, it is apparent that the essence of each of these types is controlled when one controls the particular specification.

Government control under this strategy thus incorporates two general characteristics: (a) it is an approximation of total control; and (b) it purports to control development by time but also controls by requirement type.

Anyone who would track the migration of government in-house control philosophy from the 375 series of McNamara's era through the 800 series after Packard, would recognize decentralization as a major issue. Where the project offices still have required blocks to go through in developing their program, the number of mandatory and centrally controlled blocks are reduced.

Beyond the abortive reconsideration of mission requirement control inherent in the disengagement contracting experiments, there has been only little concern about how much such extensive control costs the government. Certainly the prerogatives of control carry with them the real contractual costs of assumed responsibility. Is it possible that the costs outweigh the benefits of control? Is there a marginal utility on control? Perhaps some leaders are starting to look tangentially at this issue.

Recently, the program director of the CX Program hinted at a strategy of selective control: "We will specify the length of the runway the aircraft must stop in rather than the type of brakes."(2)

This emphasis on operational characteristics over design details can, of course, mean many things. At one extreme it can mean no control or delayed control of the Part II CI Spec. It could also mean a clear attempt at purging detail requirements from the system specification or Part I CI Spec. At the other extreme, it could mean baseline control as usual with the contractor filling in design details as they deem appropriate. At its first extreme, the control method is described in Figure 7:

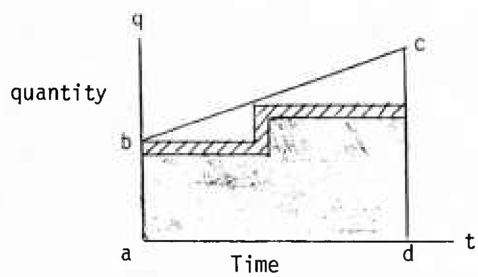

Figure 7. Operational Characteristic Control

The essential difference from the baseline model is the lack of the third step (compare Figure 6 and Figure 7). This is important in two ways. First, it clearly steps away from total control which may evoke many changes in the government/contractor relationship beyond the effect of the specific requirements uncontrolled. Second, it takes the bulk of the requirements out of government control. Design requirements easily outnumber all other types combined.

Recommendations. The intent of this paper is not to recommend any strategy over another, or even find fault with previous strategies. The paper needs to be understood in the context of the research that stimulated it. The research was basic research attempting to gain better fundamental understanding of the definition and management of requirements. The thrust was to do what had not been done--pay specific attention to, i.e. research, requirement control strategy. From the foundation laid by the research we are: (a) proposing recommendations that can and should be implemented by management now and (b) recommending research avenues of inquiry necessary to build upon the foundation and lead to future management improvements.

Given the research difficulty in categorizing and defining requirement types, it would appear that contractors may have the same level of difficulty in understanding the requirement. Specifications can be written to more clearly describe requirements by type. As a start, a highly constrained

subset of the system specification can be defined as true mission requirements and segregated. On the other end, design details can be purged from Part I CI Specs and placed in the Part II Specs. Short, non-redundant requirement statements can be written and consideration given to minimizing explanatory comments--design notes not requiring compliance might be one possibility here.

Interestingly enough, this scrubbing of standard specification and reformatting might generate benefits of clarity beyond those of segregating requirement types.

Once specifications can be more clearly correlated with requirement types, strategy comparisons could be made. A small number of representative programs (aircraft, engine, avionics, and space) could be selected as a pilot test to evaluate reactions by industry.

The second near-term recommendation offered seeks to improve the institutional structure to manage requirements. The Statement of Operational Need/ Mission Element Need Statement/Defense System Acquisition Review Council (SON/MENS/DSARC) process has been established to control basic needs and mission requirements external to the program office and the acquisition agency. The Configuration Control Board (CCB) operates internal to the program office to manage and control changes to existing requirements. We propose that a Requirements Control Board be established between these two levels to filter and manage requirements placed on the program. This mechanism would permit and encourage trade-off and debate on the need for a requirement change outside the CCB and below top management.

Since the research was basic in nature, we have several recommendations for extending and continuing the research. We feel continued research is necessary to build upon the foundation started or modify it. The following avenues of inquiry are recommended:

a. Variations of the methodology used for this research should be applied on programs involving different technologies and extended further into the product development and product life cycle. This would permit improved understanding of the growth of design requirements into the Part II Spec management arena.

b. This research effort did not examine the requirements categories of management specification and standards, legal obligations, and programming requirements. Basic research into the definition and management of these requirements is necessary to improve understanding outside of the technical area.

c. This research concentrated on requirements under direct control of the government. Effort should be initiated to gain improved understanding of contractors' response mechanisms to those requirements and operation of their own control systems. The overall process operates at the boundary between industry and government. We need to understand both sides of the interface.

d. The original rationale was to understand requirements management in order to eventually lead to improving cost control. After a confirmed methodology is established to define and measure requirements, there is a need to correlate those measures to costs and search for meaningful linkages.

e. An alternative parameter to define and track, instead of requirements themselves, would be to define the test and compliance requirements associated with each of the categories identified in the Strayer/Lockwood taxonomy. The idea is that a requirement that has no control for compliance may be empty. An improved understanding of the growth of compliance requirements may lead to implications improving overall management strategy for requirement definition and control.

f. Recognizing the ingrained nature of free enterprise weapon system development in America, one is led down the road explored by the previous recommendations. Namely, how much control does the government exercise over the companies who control requirement growth? The basic cost assumption is that this is a possible question concerning the marginal utility of control. The probability of avoiding an unsatisfactory product may (or may not) increase as government control increases; but, if it does, the marginal increase may not be worth the marginal cost. Certainly this is a worthy subject for strategy consideration.

Studies of weapon development in other cultures, notably the French, raise consideration of requirements control to a higher level. Particularly, what about controlling requirement growth directly? In the French millieu, the industry is essentially captured by the government. However, their weapons, aircraft in particular, enjoy marked performance success despite severe resource limitation. A Rand study of this system(7) concluded that the government and industry worked together "more as partners than as mutual adversaries." A key reason that they could do this was the emphasis on small stable design teams first established from the cream of the professional crop. These teams then intensify their professionalism and focus it on a common subset of design. Along the way a closed culture of norms, definitions, and understandings arise. This closed culture is a self-evaluating and adjusting one based on technical interaction and the situation rather than externally generated rules and government practice. It leads to quality of control rather than quantity. In fact, recognized experts working solely in the depths of their own expertise have great license for self-control. It's only at the boundaries that the group controls. Since the culture is focused around design rather than control of people who do design, it directly relates to requirement growth. If one follows this line of reasoning, and if one is convinced that the French are more efficient weapon producers than Americans (a set of propositions which needs more comparative analysis), then an argument for <u>quality</u> of requirement control arises.

Closing. One does not wipe out 200 years of American free enterprise based on such nebulous analyses. If it is inevitable that the American system will only change incrementally, is there a direction indicated by the French studies? One must start with the premise that we will still control the people who control requirements. Control, however, is said to be essentially a function of power and communication. Contracts, rewards, and penalties are essentially manifestations of power. Management systems, baseline control, and formal reporting requirements are communications systems tied to comparing contractor effort with their contract for selective (and often subjective) exercise of reward or penalty power. If one follows the French lead, he might search for ways to improve the quality of communication. One possible way is to encourage closure of a design culture around definitions of requirement types, relative relationships, and preferred growth patterns. The anticipated result would be sufficiently clear communications such that both sides would know enough to allow self-control in the core expertise areas and mutual resolution at the boundaries. The American economy demands we change. We can either react with more of what we've been doing or change our perspective. It would seem that increased attention to requirements is focusing on the doughnut and not the hole!

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AFFORDABILITY - NOT A DIRTY WORD

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ABSTRACT

This paper argues that affordability considerations can if properly implemented, improve the system acquisition process. Proper emphasis on affordability could stabilize or reverse negative trends that have developed in the system acquisition process. OSD policy makers and acquisition process practitioners should avoid mandating "affordability rules". Unless implementing policies are well conceived, communicated accurately throughout the DOD budget and acquisition communities, and are well understood by the practitioners, a real potential exists for the system to "screw-it-up".

The author defines "affordability" in simple, easy to understand terms and the mechanics of establishing "affordability regions" are outlined. Suggestions as to how one applies the concept are offered. Proper application will assist decision makers in reconciling needs with available resources.

The application must be from the top down and only in the macro sense. Thus its greatest benefit will be to high level management in making a first rough prioritization of needs.

Further, affordability analyses provide a linkage between PPBS and DSARC decisions. This linkage will enable more rapid agreement on resource allocations and hopefully a reduction in decisions revisited.

The author concludes by advocating an optimistic, unified approach toward use of the affordability concept while cautioning against over institutionalization and interpretation to the point the concept fails to be useful to the decision maker and a burden to those in the acquisition trenches.

AFFORDABILITY - NOT A DIRTY WORD

THE PROBLEM! It is this author's opinion that we are on the road to fulfilling a prophecy; the front end of the DOD acquisition process is about to lengthen...again!

On the average, the total time to develop a new aircraft to IOC has been increasing at a rate of three months per year, each year, for the past 15 years (1). At the same time, the interval from design contract award to first flight has remained approximately constant. There is no reason that we should be adding costly administrative time....but it will continue to happen unless high level attention is focused on the acquisition process.

The Office of Management and Budget, with the issuance of Circular A-109, defined the start of the acquisition process....Milestone Zero. How Milestone Zero is institutionalized is critical. If it is treated, as it should be, as a notification of intent to investigate and evaluate alternative courses of action to fulfill a need, there should be no lengthening of the process. But, there are indications that were about to screw it up....and demand more.

At Milestone Zero it is certainly reasonable to expect a service sponsoring a program initiation to have an initial plan of action, strategy if you like, for arriving at Milestone I.

However, it is unreasonable to expect a complete acquisition strategy, impact statements for manpower, reliability, NATO RSI, Life Cycle Cost, etc....to the point where a preferred solution emerges....it is my understanding that such activity is properly concept formulation. And, that is what approval at Milestone Zero....is specifically designed to authorize!

Unfortunately, the first few years' experience with implementation of A-109 within the DOD indicates a strong proclivity to put the concept formulation cart in front of the Milestone Zero horse. This institutional weakness must be recognized and the propensity redressed....with vigor! Or....we'll have a Milestone Zero Prime next.

Since affordability is at the leading edge of the problem and....judging by some recent writing....already subject to interpretive

misunderstanding....let's look at the concept, its value and intent.

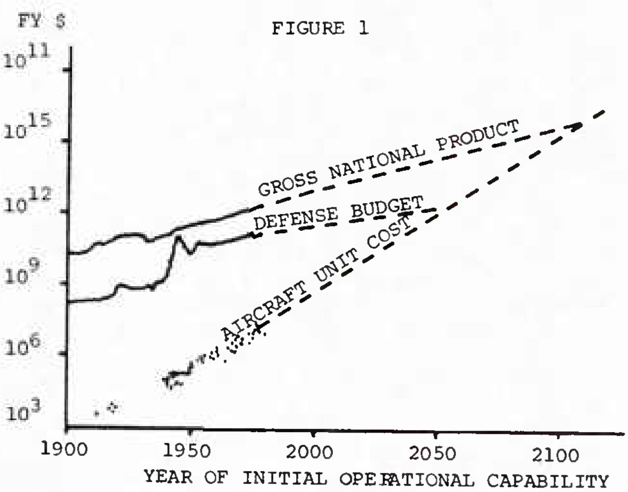
Why Affordability? This paper advances the thesis that improvement in the acquisition process can be achieved -- depending upon how the DOD and the services tackle and solve the issue of weapon system affordability. Most knowledgeable participants and observers now recognize that the services have more programs in development than can be produced and deployed, given current and projected budgetary support. The 1979 Defense Science Board Summer Study determined that to maintain current inventory numbers with projected procurement budgets would require an approximate 40% reduction in unit cost. Or....real increases in the defense budget of 17%.

The process of planning, developing and acquiring weapon systems has taken on the onerous characteristics of government oversight regulatory agencies. The process is administratively cumbersome, excessively time consuming and is becoming downright counterproductive. Coherent acquisition policies are lacking and difficult to forge between different spheres of influence.

There are real....although largely unquantifiable....dollar costs associated with this inefficiency and in not fielding hardware efficiently. It hurts our defense posture....and we can lose the game....if our reaction-action cycle takes too long.

Costs of new equipment are increasing at a faster rate than the DOD budget (see Figure 1).

FIGURE 1



Notwithstanding increased public sympathy for larger defense budgets, OMB policy has fixed the DOD budget as a percentage of the GNP (about 5%) thus tying defense budget growth to GNP growth. The average rate of GNP growth over the past four decades has gradually slowed from 4.8% in the 1940s to 2.9% in the 1970s. Given current economic trend indicators, it is unlikely that the 1980s will bring a quick reversal of this trend.

Analysis shows that the DOD and service budgets have historically been a set percentage of the President's budget request, factored for predictable cuts and inflationary effect. A sobering conclusion is that the DOD and the services must concentrate their declining purchasing power on the most important things....and that means fewer things. Even if real growth in the Defense Budget is obtained the cost of sophistication will still force difficult decisions.

The crux of the problem is....how to go about doing that, i.e., how to determine how many "most important things" to concentrate on. That is where affordability analyses can help.

Background. DOD and the services historically have not done well in coming to grips with the problem of program oversubscription because of two countervailing factors inherent in the DOD planning and program execution process.

- o New, low level efforts seem affordable when first appearing in the R&D budget, but
- o As programs evolve they gain momentum, constituencies, and collectively add up to more than can be afforded when costed out over the longer term.

At the national level this problem is being dealt with more effectively as a result of the Budget Control Act of 1974. The act requires Congress to institute restraint in the process establishing budget ceilings. Within the Executive Branch, the issuance of OMB Circular A-109 represents a companion attempt to constrain the pursuit of new programs in all federal agencies to only those that address a need that has been agreed upon previously by the Agency Head. (In the case of DOD, A-109 requires agreement between SECDEF and the applicable service secretary.)

Since mission area budgeting has been mandated by Congress on all federal agencies, it follows that mission area analysis must be linked closely to the planning, programming, budgeting system (PPBS). A useful linkage is marrying mission area and affordability analysis in the

services' planning, programming, and budgeting system.

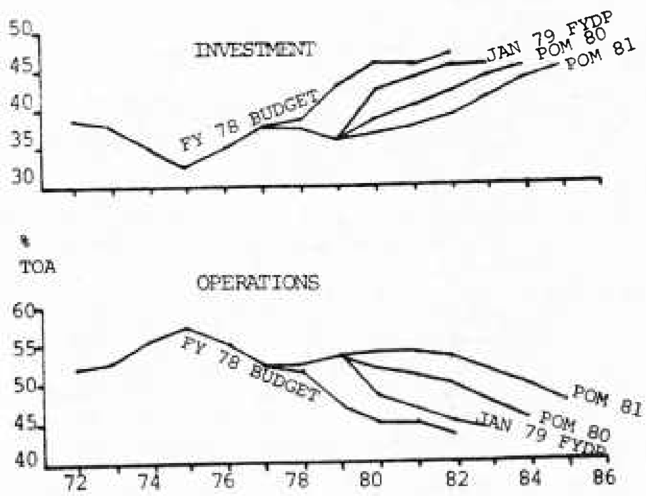
What is Affordability? What A-109 is looking for is a responsible top down look at needs, priorities and availability of resources. Let's not define, interpret and policy A-109 into an institutional monster.

If we adopt the simple explanation that affordability is nothing more than evaluation of total needs in relation to anticipated resource availability — it becomes evident that mission area breakdowns form a structure for an affordability analysis which can be a very useful tool in building the annual program objective memorandum (POM). The POM becomes less difficult to construct once mission area priorities and gross affordability projections are established. The sum of such projections results in a first approximation of the POM for the given annual period under consideration. This same approach can be applied with ease to any appropriations, categories or functional areas that are useful and make sense.

Going back to the observation made at the beginning of this paper concerning the relative predictability of the DOD budget top line, it becomes obvious that DOD and the services should conduct their hard core planning using realistic budget projections. The divergence between the President's budget and eventual appropriations needs to be kept in focus too. No sense deceiving ourselves by planning seriously for funding levels that realistically will never materialize. These relationships are depicted in Figure 2.

FIGURE 2

DOLLAR TRENDS BY TYPE OF EXPENDITURE



The disparity shown in Figure 2 between budget planning and budget reality and between investment versus operations expenditures raises difficult choices. Figure 2 shows that in recent years more is planned in the investment category than can be expected to be realized. In the operations category we see that it is costing more and more to operate and maintain fewer assets.

FIGURE 3

FUNDING PROJECTIONS

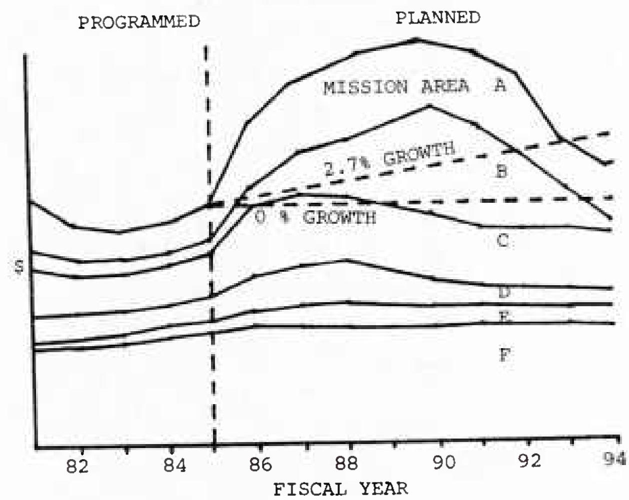


Figure 3 expands upon Figure 2 and shows even more dramatically the dichotomy between programs as planned and realistically available funding. Figure 3 is representative of requirements and planning demands. To the extent the bow wave represents unconstrained planning....it is not a real problem. To the extent the bow wave has resources applied in the FYDP....we may be wasting dollars. The outyear projections do not represent the precise magnitude of the problem....but it is clear a problem exists.

Applying the Affordability Concept. How do you come to grips with the situation just described? You can start by projecting the resources ($s) that can realistically be expected within some boundary conditions; e.g., no change, tied to GNP growth, GNP decrease, etc. This can be done by use of historical data or, to be analytically sophisticated, by a linear regression of past budgets.

Refering back to Figures 2 and 3, the task of deciding on affordability of larger mission area aggregations boils down to structuring a set of "Figure 3" type affordability ranges such that the combined upper limits of each do not exceed the investment resources projected to be

available over the time period in question. And, by applying bounds on the bow wave described above, a review of the needs and a prioritization of the programs to fulfill those needs will be a logical fall out. You will be looking at the outyear effect of today's decisions....a useful perspective for the decision maker.

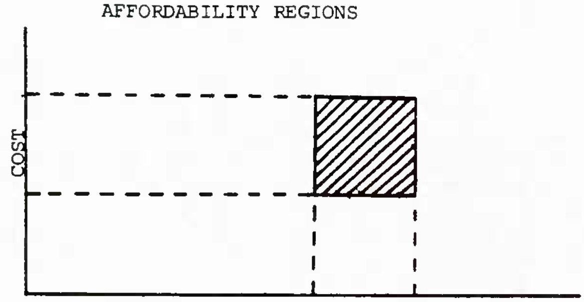
Further, in reviewing the needs you will undoubtedly find that there are some options -

- o Keep the weapon system longer
- o buy more of the same
- o modify the system
- o buy a lesser capability system developed elsewhere
  or
- o develop a new system.

In short, there is a range of capability and a range in cost that can be dubbed an affordability region....you can diagram it as in Figure 4. How you develop the various mission area affordability boundaries involves judgment, overall perspective of mission priorities, etc. In short, it is not rigorous and the temptation to "model" affordability should be be resisted.

FIGURE 4

AFFORDABILITY REGIONS



A note of caution. There are already spokesmen on the street linking affordability directly to tradeoff considerations at the program manager level. Wrong! Affordability is the link between the planning, programming and budgeting (PPBS) and acquisition processes. DODD 5000.1 and 5000.2 say so.

"Affordability" is most useful as a macro management tool. Program managers should be aware of the concept -- but they cannot set their own program's region of affordability -- the service or agency head must determine the boundaries -- program managers provide input to the process and test the boundaries for feasibility in an iterative process....<u>if</u> required.

This clearly says that affordability regions or boundaries are approximations and certainly subject to change with time or in reaction to changes in other mission areas. Therefore, rigid procedural rules should not be mandated for "affordability". It is primarily for senior management use in making the first screen of the "need" and establishing the feasibility of financing the acquisition within anticipated resources. Once a program is established, its "affordability" and yearly funding is governed by the budgetary process.

Previous attempts at coming to grips with the general problems of individual program cost/affordability gave rise to design-to-cost, life cycle cost, concurrency, fly-before-buy, and total package procurement techniques that have met with varying degrees of success. As was the case with these techniques the precedent is strong for the affordability concept to gain institutional acceptance, but to fail totally in producing improvement in the acquisition process.

The spotty success of the cited techniques can be attributed in part to premature or misapplication of the techniques. In turn, the misapplication of these techniques stemmed in the main from a tendency to mandate their use from on high without communicating adequately and accurately the limitations of these techniques to those who have to figure out the details and mechanics of real life implementation.

"Rules", unless well conceived, communicated, and understood accurately and clearly throughout the DOD budget and acquisition communities, will fail; let's not tar affordability with the same brush as previous concepts devised to induce improvement in the acquisition process.

<u>Benefits to be realized</u>. Successful application of the affordability concept <u>should</u> result in:

- o Quicker agreement on resource allocation decisions -- program starts
- o Improvement in the ratio of "planning/administrative" to "doing" time
- o Reduction in inefficiencies occasioned by "program turbulence" that stems from the tendency to revisit program decisions made previously

Quicker agreement on resource allocation decisions can induce substantial savings or cost avoidance -- particularly in a period of rapid inflation such as we are now experiencing. In turn it is judged that quicker agreement on resource allocation decisions, while maintaining the quality of such decisions, can only stem from reducing the number of tradeoff decisions that have to be made. To do that, one must embark on a deliberate attempt to group tradeoff decisions into "packages" so that the overall number of tradeoff decisions necessary to be made in a given budget cycle is reduced to more manageable proportions.

This can be easily accomplished if requirements (needs) are grouped by mission area and forwarded with the POM....just as OSD is now directing. What OSD needs to do is develop a means to review the needs annually with the POM so the process can be speeded up.

There should always be room for out of cycle effort....and there is. But, the track record for out of cycle "needs" consideration is poor and inherent delays slip such efforts into the next cycle.

OSD Implementation. Implementation of A-109 within the DOD is working to the extent that a better dialogue between the OSD and the services seems to be developing. However, agreement on needs seems exceedingly difficult to come by and delays are cropping up as program efforts previously begun are stretched out pending agreement on the underlying need to which they are designed to respond. Much of this is bureaucratic haggling of little substance, created by misunderstanding and lack of knowledge as to the purpose and intent of A-109.

Here, in the author's view the process can be speeded up an improved substantially if the SECDEF and the Service secretaries could agree on a procedure whereby:

- o The service conducts the mission area analysis, prepares applicable mission element need statements (MENS), and submits them during the budget cycle to SECDEF. (DOD Directives 5000.1/.2, just revised, support this)
- o The MENS is submitted as a notification document -- the intent being to notify SECDEF and OSD acquisition personnel that unless otherwise directed, the service will proceed as indicated

The SECDEF should review these needs annually in the context of broad mission categories and budget projections -- a top down, macro look. Involvement of Service Secretaries and Chiefs would establish the proper framework and baseline for subsequent budgetary and planning activity to carry out the decisions. Such top level OSD involvement in mission area tradeoff decision making and prioritization would enable each DOD component to prioritize effort more rationally within each mission area.

To preclude overload, it is essential that high level decision makers dwell only on high level aggregations of tradeoffs. It is the mission capability to be achieved that the Secretary of Defense and members of the DRB and JCS are really interested in....not programmatic detail.

As developed previously, the difficulty in deciding on the affordability of any agreed upon need is obviously when needs oversubscribe the resources projected to be available. The wide range of efforts planned or underway at any given time within the DOD and the diversity of opinion concerning the worth of one effort versus another will often preclude agreement between organizational levels concerning the proper affordability of the need. However, if the services and OSD agree on the recommended implementation procedures noted above, there should be little difficulty in checking affordability and processing MENS.

The tools for an OSD affordability check are available in current PPBS documentation; the Extended Planning Annex (EPA), the FYDP, and the POMs from each service. Using these, OSD can make its first rough cut on the problem and begin to rationalize priorities from the top down. Proper application of this policy would contribute toward measurable improvement in the development/acquisition process.

SERVICE IMPLEMENTATION. OSD has clearly provided the framework. Revised directives and amplifying memorandum have emphasized the desire for the MENS (or its equivalent) to be the basis for a program's inclusion in the POM. Current DOD acquisition ground rules preclude commencement of any effort that is not related directly to prior, SECDEF/Service Secretary agreed-upon need, and no funding is to be included in the budget for program effort that cannot be related directly to a prior SECDEF/Service Secretary agreed upon need (2).

At the same time, current OMB/OSD policy requires DOD and the Service to "reconcile the need" against resources available/necessary to satisfy that need whenever the Service seeks agreement from SECDEF regarding a Mission Element Need Statement (MENS). Thus it would appear incumbent upon the service to develop an affordability analysis in conjunction with developing the MENS.

This same analysis must be used by the services to construct their POM. The Navy has used this process for some time in conjunction with POM development. Through rational programmatic choices efforts are slowed, cancelled or deferred until the total funding requirement is brought within the bounds of resource projections.

The affordability linkage continues throughout a program's acquisition cycle. DODD 5000.1/.2 specifically require an affordability consideration at each milestone. Annual POM development provides the check. The only disconnect that can occur is a dramatic change in priorities occasioned by changes in the

threat, funding constraints, or perspectives of the principal participants.

In the author's view, the most practical means of simplifying this divergence of opinion and hence the entire R&D/Acquisition management problem is to embrace the concept of affordability as outlined herein and to strive to perfect the technique as we go. There are some pitfalls that we must avoid as we progress, as noted. They are not so overpowering that utilization of the affordability concept should be delayed while we debate the pros and cons. The services should be encouraged to apply the the concept in the context of budgetary techniques already in place or in development.

Summary. There is no question but what all serious, thinking persons involved in the DOD development/acquisition process recognize. Improved means must be devised to stabilize or reverse the trends discussed at the beginning of this paper. Improved means must be found for reducing the administrative/overhead cost of the DOD acquisition process.

Significant savings in the total cost of acquiring weapon systems can be realized by shortening the lead time necessary to progress from program initiations to fleet/unit operational introduction. Significant savings in lead times are judged possible by simplifying the process through which each service individually and the DOD collectively determines whether or not a given effort is affordable.

Since opinions differ radically concerning what is affordable, it is beneficial to establish procedures reasonably common to the services and OSD for agreeing on the affordability of given efforts in relation to others. In attempting to agree on the "worth" or affordability of a given effort, the parties obviously must first agree on the relative priorities of the efforts underway or contemplated.

An optimistic, positive approach toward use of the affordability concept is encouraged. It is important that all concerned understand what the concept is and what it is not. It will be tempting to devise homogenous, across-the-board OSD rules governing the application of the affordability concept — which we are not smart enough to devise....so let's avoid that trap.

The affordability concept is useful. Its proponents can gain greater support if they avoid being overzealous. Similarly, those who see only the pitfalls should view the concept with less reluctance and be receptive to the efforts those who see affordability as a positive step in improving the DOD development/acquisition process.

On a more general note, it is the author's concluding opinion that many of the practitioners of the development/acquisition process tend to make the process more complicated than need be. The basic policy permits considerable flexibility and it should be exercised accordingly.

Greater use of the procedure of simple notification as to intent to proceed unless otherwise directed should be encouraged and such a procedure adopted more widely in lieu of the long, drawn out, "negotiations" between OSD and the services that currently characterize the process. Quite simply....we can't afford it!

1. Augustine, Norman R., "Augustine's Laws and Major System Development Programs", Defense Systems Management Review, 2:2 (Spring 1979)
2. USDR&E memo of 25 January 1980.

THE DOD AFFORDABILITY POLICY

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ABSTRACT

This paper traces the progress of the Department of Defense (DoD) acquisition policy initiative on affordability. The affordability problem is defined as a financial condition in which more systems are developed than can be procured and deployed with anticipated defense budgets. The causes of the problem are enumerated. The ensuing fiscal backlog or "bow wave" phenomenon is described as are its costly reconciliations in program stretch-outs, deferrals, and other disruptions. Factors determining a system's affordability are identified. DoD's evolved affordability policy is described in detail together with implementing changes that have been made to the Mission Element Need Statement/ Defense Systems Acquisition Review Council process. Necessary interfaces with the Planning, Programming and Budgetary System process and the long range planning function are discussed.

PROBLEM STATEMENT

The single greatest problem facing the U.S. defense community is acknowledged to be the affordability problem. Simply stated, DoD has more systems in development and production than it can produce and deploy within existing and projected fiscal budgets. Faced with this monetary dilemma and still determined to keep all its urgently needed programs going, the DoD is forced to defer the transition to production of programs in development or stretch programs already in production.

This process of balancing instant year requirements with the budget serves to shift major segments of procurements to subsequent years and has a layering effect termed the bow wave phenomenon. The bow wave is most pronounced in the procurement accounts but exists in the RDT&E appropriations as well. A further compounding of the problem takes place when reduced funding of any one program causes a predictable decrease in the number of units that can be procured. A reduction in the annual buy causes diseconomies of scale in purchase of components and supplier parts, delays in learning curve performance in assembly, and proportionally higher overhead and administrative costs by the contractors and Government agencies alike. The result is a dramatic increase in unit cost. Additive to the above are the escalation costs when the procurements are shifted to the out-years.

The increased cost to our defense is a serious consequence in itself; however, there is an attendant decrease in military capability. Deferred transition from development to production lengthens the acquisition cycle, postpones achieving initial and final operational capabilities and reduces the effective inventory life of a system before the onset of technological obsolescence.

Furthermore, inventory and force level trends are downward. The average age of our equipment is increasing. We are not procuring sufficient materiel in some categories, tactical aircraft is one, to compensate for attrition and consumption. We also rob our operations and maintenance accounts to partially offset procurement fund deficits. This stop gap remedy leads to decreased availability and utilization of the equipment already fielded. To the extent the problem precludes ability to execute the prescribed land, air, and sea wartime scenarios, it can be said that affordability is now dictating national defense strategy.

DEFINITION

Affordability is the ability to program and budget adequate resources to execute a program in an efficient and effective manner. It is the ability to develop and procure a system for inventory without resorting to schedule stretch-outs and low, uneconomical production rates.

From the Office of the Secretary of Defense (OSD) vantage point, this definition is aimed at answering the question of how much the Military Department(s) is prepared to commit of its current and projected resources to develop, acquire and field a system which will satisfy a given military need. Although the problem and its definition includes the deployment phase, this paper concentrates on acquisition.

Affordability should not be thought of as a design discipline; rather, it is coming to grips with fiscal reality. Affordability is not a buzz word or the basis of a cult; it is everybody's practical problem.

CONTRIBUTING CAUSES

There are many reasons for the growing acuteness of the affordability problem. Increasing complexity and sophistication and rising personnel costs have made our systems more expensive. A new system is

4½ times as costly as the one it replaces, or according to another estimate, increases in cost 5 to 6% per year. We have suffered large investment losses when systems have been terminated, e.g., B-70, MBT-70, Cheyenne, only to be later reinstated as new but more expensive programs. Despite emphasis on system reliability and maintainability characteristics, operation and support costs continue to rise, thereby consuming funds that might go for inventory procurements or greater utilization.

Although we have worked very conscientiously on improving our cost estimating capability, we are still plagued with the submittal of low cost estimates. In the desire to obtain program approval, there is a natural temptation to underestimate costs or provide insufficient reserves. Once the program is underway there are motivations to increasing its size and scope. We have not sufficiently incentivised management to reduce cost.

Our cost models need improvement particularly in regard to future operation and support cost predictions. We need to develop the ability to track actual operating costs with previous projections.

Our Military Services have an understandable inclination to start and pursue too many programs; hence, drive up their budget requests. There is competition in and among the Services for funding within and among mission areas. It is natural to ask for more knowing one must settle for less.

Finally, when marginally justifiable programs are started they rapidly gain momentum and "conclaves of advocacy" which are extremely difficult to deny. It is virtually impossible to cancel a marginal program until it collapses from the sheer weight of its technical difficulties or financial excesses.

AFFORDABILITY FACTORS

Three factors determine if a given program or system is affordable. The first factor is quite logically what it will cost in resources of dollars and manpower. The second is the priority the system commands within its mission area. If the cost is high this priority may have to take on national significance, e.g., the MX. The third factor is the existence of other demands for resources within that mission area. Is there "room" for the given program or are there too many programs relative to the size of the budget? This last factor is not one intrinsic to the program itself and explains why an otherwise technically successful, well managed program generally meeting its performance, cost and schedule can become a candidate for cancellation. The Marine Corps AV-8B Harrier is a case in point.

BUDGET TRENDS

Affordability is the problem it is today because we are no longer in an era where pursuit of technology and ultimate performance is in vogue; where funds are available to produce every quantitatively superior weapon that can be developed. Over the past 3 decades Federal spending has exhibited a fairly linear increase of about $10 billion per year in constant FY 1979 dollars while the DoD budget has been essentially level. The defense budget has been declining as a percentage of gross national product and of total Federal spending. The trend in procurement appropriations in constant dollars is downward. Procurement funding has declined as a percentage of the total defense budget. These trends in the budget are shown in Figure 1.

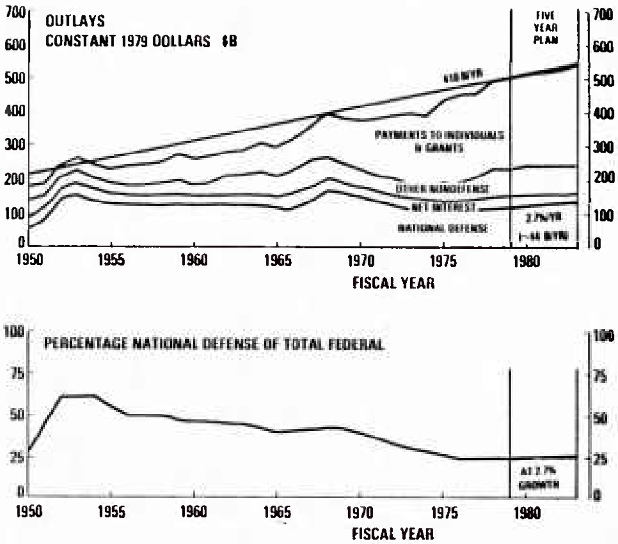

Figure 1. Federal Budget Trends

The Administration has proposed a 5% growth in the defense budget and a corresponding increase in procurement accounts. History shows that congressional enactments would not tend to sustain such an increase and that our long range planning might be based realistically on zero growth.

PROBLEM SIZING PERSPECTIVES

The funding bow wave is not a newly identified or observed phenomenon. A 1977 Defense Science Board (DSB) task force report[1] on the defense acquisition cycle estimated that these bow waves averaged 30% higher than the budget in the procurement accounts. The 1979 DSB task force report[2] on reducing the unit cost of equipment concluded that maintaining our inventory with the current procurement budget would require roughly a 40% reduction in average unit cost.

The absolute magnitude of the problem varies based on one's perspective in viewing the military resource requirements. Most analyses of the bow wave quite naturally use the Defense Five Year Defense Plan (FYDP) and Extended Planning Annex (EPA) to determine what funds are necessary to meet our mission needs. Such a requirement's "topline" is then compared to a projection of the budget based on historical trends and current events to resolve the bow wave. Such a resolution is shown in Figure 2 for one of the Military Departments. The graph was constructed by the OSD Comptroller.

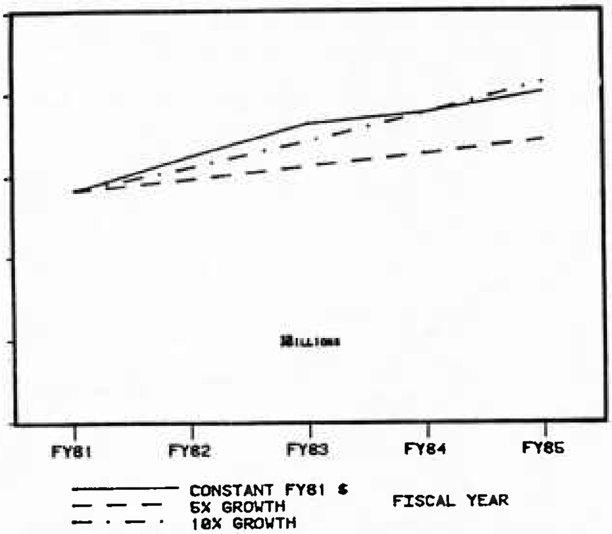

Figure 2. Military Department Procurement Budget

The behavior of a typical procurement bow wave in one of the Military Department's mission areas is depicted by Figure 3. Faced with insufficient funding in FY 1978, part of the requirement is deferred to the next succeeding year. In this case, although an increase in real dollars was then made available, the new amount is again insufficient and the bow wave continues. The lower portion of the graph shows how support funds, i.e., funds for buying other than the end item, e.g., spares, are adjusted to trade off readiness for inventory or vice versa.

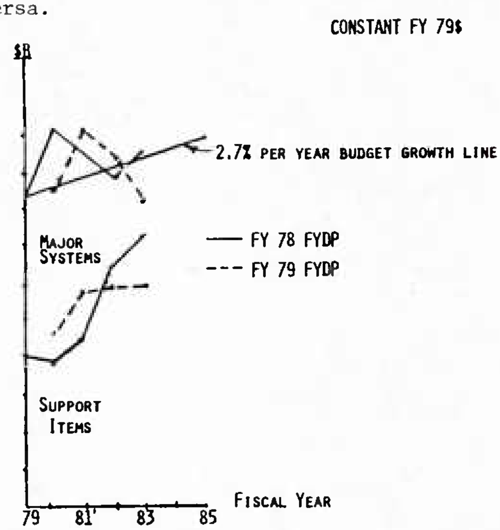

Figure 3. Typical Mission Area Procurement Program

The perspective taken in Figures 2 and 3 leads one to believe the problem is manageable, if we could only realize a meaningful increase in the defense budget. Five and 10% budget increase lines have been added to Figure 2. The larger increase appears to solve the problem.

A different picture of the problem is obtained if our perspective of the resources required is based on funding needed to meet our authorized acquisition objectives (AAO's) which were developed from Presidential Directives and Decision Memoranda that set our national defense policies and strategies as subsequently interpreted by annual Defense Consolidated Guidance. Unfortunately, the FYDP, constructed by the Military Departments, taking into consideration defense fiscal guidance, falls short of enabling them to equip and sustain their forces to the degree dictated by wartime scenarios. We ask the Military Departments to prepare and accomplish much more than Congressional appropriations will allow.

The Figure 2 perspective also underestimates the problem by making the origins of the funds required and projected funds available line coincident. In fact, we start or carry over each year a large backlog, or bow wave if you prefer, of unanswered fund requirements to satisfy underequipped units, inadequate spares provisioning, depleted stockages and other legitimate requirements. A graph depicting the secondly described perspective is shown at Figure 4.

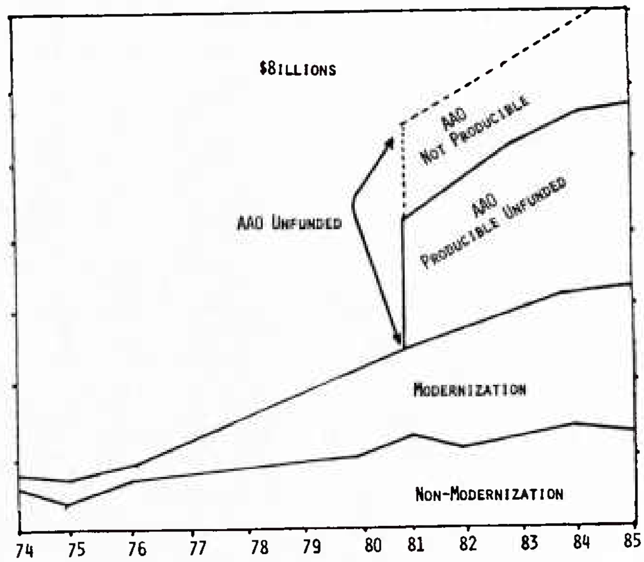

Figure 4. Procurement Bow Wave

Figure 4 plots the FYDP line, as at first, for one of the Military Department's procurement accounts. Superimposed on the FYDP period years is an area representing expenditures for equipment that could be made toward meeting the Military Department's AAO. The portion of this area labeled "producible unfunded" represents materiel that could be procured and delivered against the end of the period requirement using existing facilities and reasonable build-ups in production rate.

As might be expected, the disparity between the AAO and the budget is also widening. Figure 4 was developed in support of testimony given to the Congress on the FY 1981 budget. A similar graph was prepared in connection with the FY 1980 budget. Between years, the total AAO unfunded area increased $26 billion for the FYDP period.

PROBLEM VISIBILITY

Our inability to buy planned annual quantities of our major systems and their accompanying unit cost increases are evident to the Congress. A Congressional Budget Office (CBO) analysis[3] of the FY 1981 DoD procurement budget shows that although a 4.7% real dollar growth in procurement was proposed, the number of aircraft and land force systems to be acquired was down compared to the previous year's budget submittal. For example, the number of aircraft in the FY 1981 budget when submitted was 466 which is 173 aircraft or 27% less than the planned FY 1981 program submitted with the FY 1980 budget.

Table 1. Variation in FY 1981 Program Planning and Unit Cost

Aircraft	FY 1981 Planned Procurement in FY 1980 Budget Submittal		FY 1981 Planned Procurement in FY 1981 Budget Submittal	
	Quantity	Unit Cost	Quantity	Unit Cost
UA-60A Blackhawk Helicopter	145	$2.4M	80	$3.8M
EA-6B Electronic Jamming	6	28.5M	3	43.8M
EC-130 Q Airborne Communication	3	25.6M	1	45.1M
HARM Missiles	212	0.4M	80	1.2M
A-10 Attack	106	5.8M	60	8.2M
F-15 Fighter	60	17.9M	30	24.5M
E-3A AWACS	3	100.3M	2	123.6M

Taken from the CBO analysis, a comparison of the two proposals for a number of aircraft and missile line items is shown in Table 1. The figures have not been adjusted for inflation.

Congressional committees have asked affordability questions in response to DoD testimony given on the FY 1981 budget. A typical question suggested that the bow wave could be reduced and more materiel bought with the same dollars if we concentrated on a few critical programs and deferred others. This is a course of action the DoD has broached internally but the choices entailed are very difficult. We deferred developing and fielding new equipments in favor of procuring more of existing inventory items for Southeast Asia. These items are technologically obsolete and many have had their service life extended through updating and refurbishment. They also represent a technology that presents logistic and maintenance burdens. We urgently need to procure and deploy the advances embodied in the new systems we have been developing in the 1970's.

UNIT COST AS A FUNCTION OF PRODUCTION RATE

The DoD has proceeded to study the effects of variation in production rate on unit cost. This effort is detailed in a companion paper by Mr. John C. Bemis[4]. Work to date, concentrated on the aircraft commodities, shows that significant economies can be achieved by increasing rate. Conversely, exorbitant cost increases will be the result of dropping the production rate below economical manufacturing quantities. Figure 5 shows the rate vs cost trend line obtained from normalizing data from a number of distinct aircraft programs of different types. Each program has a characteristically different curve exhibiting a point or knee below which a rate decrement would yield a sharp increase in unit cost. Mr. Bemis' paper discusses how his rate vs cost model can be used to optimize production for a given funding level and to estimate costs of program stretching and maintaining an active production line or warm base.

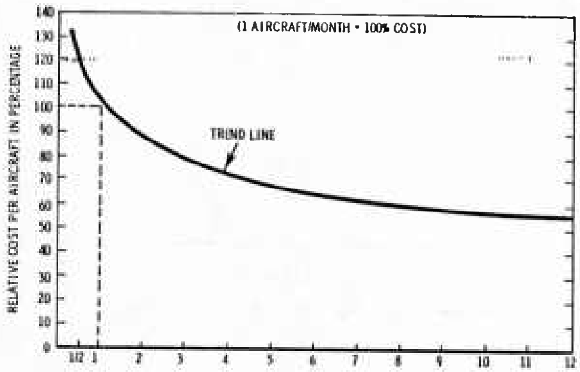

Figure 5. Sensitivity of Fixed Wing Aircraft Cost to Production Rate

POLICY INITIATIVE

Faced with its burgeoning affordability problem, the DoD established a new policy initiative in 1978. Its objective was to develop an affordability policy for major defense systems that would determine and maintain our financial capabilities to support both acquisition and deployment of these weapons within the constraints of our foreseen budgets and manning levels in the years ahead. A major goal of this initiative is to procure our equipment at economical production rates and avoid the wastes that are suffered when terminating or stretching programs that do not fit within one or more fiscal appropriations. This policy initiative was announced by the Secretary of Defense and the Under Secretary of Defense for Research and Engineering in their annual reports to the Congress for FY 1980 and staffed within the DoD during the summer of 1979.

In summary, the concept of affordability which subsequently evolved was to determine at program initiation what could be spent in order of magnitude to satisfy a military need, by prioritizing it with other elements of the same mission area and then constructing a composite program which might be pursued within the constraints of projected budgets. The costs of the program would be examined at consecutive Defense System Acquisition Review Council (DSARC) milestones in the context of being affordable within the program's mission area. Milestone II approval of Full Scale Development was identified as the major affordability decision point for major systems. The concept calls for reconciliation of the DSARC and Planning Programming and Budgeting (PPBS) processes so that the two defense management mechanisms work together, not in isolation or conflict.

DEFENSE DIRECTIVE PROVISIONS

The new DoD affordability policy has been placed in the just issued complete revisions to the two top level major system acquisition documents. Department of Defense Directive 5000.1, "Major Systems Acquisitions," dated 19 March 1980 has a new paragraph D2d entitled, "Affordability" which translates the preceedingly described policy initiative into distinct requirements applicable to each program milestone decision. This paragraph is reproduced in the Appendix.

The affordability paragraph in DoDD 5000.1 makes reference to a corresponding paragraph, E5g, in revised Department of Defense Instruction 5000.2, "Major System Acquisition Procedures," dated 19 March 1980 which itemizes the specific affordability points which will be taken into consideration at each milestone review. The DoDI paragraph is also reproduced in the Appendix.

Key to each milestone is the determination that the program can in fact be executed in the manner recommended to and subsequently directed by the Secretary of Defense. Our most costly program disruptions come about when carefully planned and contracted programs are overturned by insufficient resources. The costs of deferrals and stretch-outs are exacerbated by loss of negotiated option prices, warranties, and other valued contract provisions. Destabilizing workload effects upon the manufacturers and their vender and supplier networks work against our establishing a sound government-industry relationship. Resolution of the affordability problem would serve to greatly improve the defense image as a reliable customer.

AFFORDABILITY AND THE MISSION ELEMENT NEED STATEMENT (MENS)

Consideration of affordability begins at Milestone "0", Concept Exploration. The instructions for preparing a MENS given in enclosure 2 to DoDI 5000.2 ask the preparing DoD component to "identify key boundary conditions" of "relative priority within the mission area" and "the order of magnitude of resources the DoD component is willing to commit to satisfy the need identified." The enclosure goes on to say, "This resource estimate is for initial reconciliation of resources and needs. It is not to be considered as a program cost goal or threshold." Obviously, a program cost estimate is not possible before a concept has been selected.

The order of magnitude resources figure placed in the MENS is for the purpose of avoiding the selection of unaffordable concepts at Milestone I Demonstration and Validation, and is vital to industry in scoping the problem solution they will submit in response to the need solicitation. It is fruitless to pursue concepts which will never be produced and deployed because of insufficient funding.

AFFORDABILITY AND THE DSARC

DoDI 5000.2 is quite specific on the information to be presented to the DSARC at Milestones I, II, and III (Production and Deployment). To facilitate an assessment of funding a Resources Summary is required in the Decision Coordination Paper (DCP). This summary compares the estimated life cycle costs with the amounts approved in the FYDP for the applicable acquisition and operating and support accounts. The DoDI is positive in its resource position in stating that a favorable decision on proceeding with development or production shall not be made unless projected life cycle costs are in the FYDP and EPA. If not, the Military Department is advised to make compensating changes to other programs and identify potential budget offsets.

DSARC/PPBS COORDINATION

Both DoDD 5000.1 and DoDI 5000.2 make it clear that affordability is principally determined through the PPBS process where programs vie with one another in the context of priority of funding. The affordability objective of the DSARC is to construct individual programs so there is little likelihood Secretary of Defense programmatic decisions will be "revisited" and overturned in the budget process.

The affordability policy is an answer to the often voiced criticism that we need coordination between the DSARC and PPBS processes. The recently created Defense Resources Board (DRB) charged with overseeing the preparation of the defense budget will also promote better coordination in that both the DSARC and DRB have a similar principal membership. A number of recent DSARC decisions were held in abeyance until the DRB met and considered the programs in the light of the entire budget mission area.

LONG RANGE PLANNING INTERFACE

As previously discussed, historic budget trends indicate that despite shifts among appropriations to reflect changes in military and political emphasis, the size of the defense budget in real terms is fairly constant and predictable. This condition suggests that long range planning can be conducted with a degree of confidence as far as total funding is concerned. There is a complementary OSD initiative to improve our long range research and acquisition planning which is preparing alternative investment strategies by mission area based on budget projections in the RDT&E, Procurement and O&M accounts. Close alignment of these strategies with projected resources is key to controlling propagation of the bow wave phenomenon. Failure to address the immediate bow wave problem makes long range planning ineffectual.

The affordability problem cannot be solved or abated by small increases in the defense budget or by reasonably attainable reductions in system unit cost. Regrettably, the bow wave conditions will continue to worsen unless difficult decisions are made to forego or cancel some systems. These decisions should be made as early as possible in the acquisition life cycle to preclude loss of R&D investments and before a program develops a large degree of advocacy and momentum that makes it

extremely difficult to stop. In the long run, defeating the bow waves will have beneficial industrial market effects that ensue from increased program stability.

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1. Defense Science Board, Report of the 1977 Summer Study, "Task Force on the Acquisition Cycle," March 1978.

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4. Bemis, John C., "Production Rate as an Affordability Issue," 9th Annual Department of Defense/Federal Acquisition Institute Acquisition Research Symposium, Annapolis, MD, June 1980.

APPENDIX

DoDD 5000.1, "Major Systems Acquisition," March 19, 1980, Excerpt; Paragraph D2d, Affordability

"Affordability. Affordability shall be considered at every milestone. At Milestone 0, the order of magnitude of resources the DoD Component is willing to commit and the relative priority of the program to satisfy the need identified will be reconciled with overall capabilities, priorities, and resources. A program normally shall not proceed into Concept Exploration unless sufficient resources are or can be programed for Phase 0. Approval to proceed into the Demonstration and Validation phase shall be dependent on DoD Component assurance that it plans to acquire and operate the system and that sufficient RDT&E resources are available or can be programed to complete development. Approval to proceed into the Full-Scale Development phase shall be dependent on DoD Component assurance that resources are available or can be programed to complete development and acquisition and to operate and support the deployed system in the manner prescribed by the Secretary of Defense. This assurance will be reaffirmed by the DoD Component prior to receiving approval to proceed into the Production and Deployment phase. Affordability, a function of cost, priority, and availability of fiscal and manpower resources, shall be established and reviewed in the context of the PPBS process. Specific facets of affordability to be reviewed at milestone decision points are set forth in DoD Instruction 5000.2."

DoDI 5000.2., "Major System Acquisition Procedures," March 19, 1980, Excerpt; Paragraph E5g, Affordability

"(1) Affordability, the ability to provide adequate resources to acquire and operate a system, is principally a determination of the PPBS process. The ability to provide sufficient resources to execute a program in an efficient and effective manner is a fundamental consideration during milestone reviews. Requests or proposals to proceed into the next acquisition phase shall be accompanied by assurance that sufficient resources are or can be programed to execute the program as directed by the Secretary of Defense.

(2) The DoD Component shall describe in the MENS the general magnitude of resources it is prepared to commit to acquire a system to satisfy the need. At Milestone I, affordability considerations shall be used as a factor in determining the selection of alternative concepts. At Milestones II and III, a favorable decision shall not be made unless the system's projected life-cycle costs, including product improvement and other modifications, are within the amounts reflected in the latest Five Year Defense Plan/Extended Planning Annex (FYDP/EPA) or unless compensating changes are made to other items in the defense program.

(3) The DoD Component briefing presented to the DSARC at Milestones I, II, and III shall include the following affordability considerations:

(a) Comparison of program resource estimates with latest PPBS projections (including the extended planning annex).

(b) Identification of the relative ranking for this system and the DoD Component's other major systems in the same mission area and general time frame in the latest program or budget submission.

(c) Analysis of variation in unit cost (recurring hardware, flyaway, and procurement) with production rate (Milestones II and III).

(d) Identification of potential offsets necessary to provide the resources to execute the remaining phases of the program where program cost estimates provided to the DSARC exceed latest budget projections. Where joint programs are involved, offset identifications shall not be limited to the lead DoD Component."

MISSION ANALYSIS: A NEW EMPHASIS AT THE PRODUCT DIVISION

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ABSTRACT

Mission analysis, as defined in the new DoDI 5000.2, describes a function which the Air Force System Command's product divisions must perform pre-Milestone 0. The product divisions, those elements of the Air Force which have the responsibility for acquisition of the major weapon systems, represent the technical and managerial data base regarding major system acquisitions. Use of this basis in an analysis of the mission need is essential both to ensure that an informed decision is rendered at Milestone 0 and to enable the product division to respond in a timely manner to the directed program.

INTRODUCTION

The recently published DoD Instruction 5000.2, dated March 19, 1980, defines mission analysis as:

> . . . any assessment of current or projected U.S. military capability to perform assigned missions. Mission analysis shall normally evaluate the interplay of threat, capability, operations concepts, survivability, and other factors . . . which bear on the missions of the various Components of the Defense Department. The primary objective of the mission analysis is the identification of deficiencies, so that appropriate corrective action can be initiated. . . . (1)

Applying this definition, mission analysis becomes a seminal pre-Milestone 0 development planning function within the Air Force. It provides the necessary in-depth understanding of the mission need to enable formulation of a responsive system acquisition program. To appreciate the full impact of performing the mission analysis function, one must put it in the context of the major systems acquisition policy.

The Office of Management and Budget Circular A-109, Major Systems Acquisitions, suggests four key decision points to be applied to the acquisition of a major system by the agency head. The first of these decision points entails the:

> Identification and definition of a specific mission need to be fulfilled, the relative priority assigned within the agency, and the general magnitude of resources that may be invested. (2)

This decision point is currently the precursor to the major systems acquisition process as formulated by the former Deputy Secretary of Defense, David Packard, and is called Milestone 0 by the implementing Department of Defense Directive (DoDD 5000.1). (3)

Within the Department of Defense (DoD) a major program reaches Milestone 0 and enters the acquisition process upon approval of a Mission Element Need Statement (MENS). The process by which the MENS is reviewed and approved by the Secretary of Defense has caused a bit of consternation within the Department of Defense. (4) As of late January 1980, a total of thirteen DoD systems had officially reached Milestone 0, while an additional twenty-one MENS were in various stages of the review process. Of the thirteen, a number have had an *ex post facto* MENS.

Milestone 0 has also been cited as the start of the "birth phase" of a program. This birth phase or

> . . . "front end" begins with the official acceptance of a mission need and goes to the point where there is sufficient data to allow confident predictions about costs, performance capability, development risk, and military utility to support a commitment to full-scale development (FSD). (5)

Studies have suggested that the "birth time" of programs has lengthened significantly during the past two decades, . . . from less than two-year birth time prior to 1960 to nearly five years in the current decade. (6) Since OMB Circular A-109 has been in effect only four years, it is too soon to determine whether the requirement for the Milestone 0 decision point has, or has not, lengthened the gestation. Commentaries are cautiously optimistic at best. (7) Suffice it to say that a "decision process" precedes Milestone 0 and Milestone 0 starts the clock on the program birth time. A look at the prescribed activity that precedes this event may provide insight regarding the effect of OMB Circular A-109 on the acquisition time.

PRE-MILESTONE 0

Neither OMB Circular A-109 nor the current version of DoDD 5000.1, dated March 19,1980, details the pre-Milestone 0 activities; however, within the Air Force these activities are defined in Air Force Regulation (AFR) 57-1. (8) Figures 1 and 2 depict this prescribed pre-Milestone 0 activity. Under AFR 57-1, the operating commands are assigned the primary responsibility in the need identifications phase to ". . . analyze the basic mission tasks and assess the ability to perform (them). . ." and to ". . . document as Statement of Operational Needs (SONs) those operational needs and deficiencies . . ." (9)

In developing SONs the operating command conducts continuing analyses of its assigned segment of the defense mission and identifies needs and deficiencies or opportunities to enhance its capability through increased effectiveness or through reduced cost. This process is referred to as a Mission Area Analysis (MAA). Following identification of a need during the MAA, a SON is drafted and circulated for review by appropriate sister commands. Reviewing elements include those which may eventually be directed to satisfy the need -- the product divisions. Resultant comments are considered by the operating command in the preparation of the final SON, which is ultimately forwarded to Hq Air Force for processing.

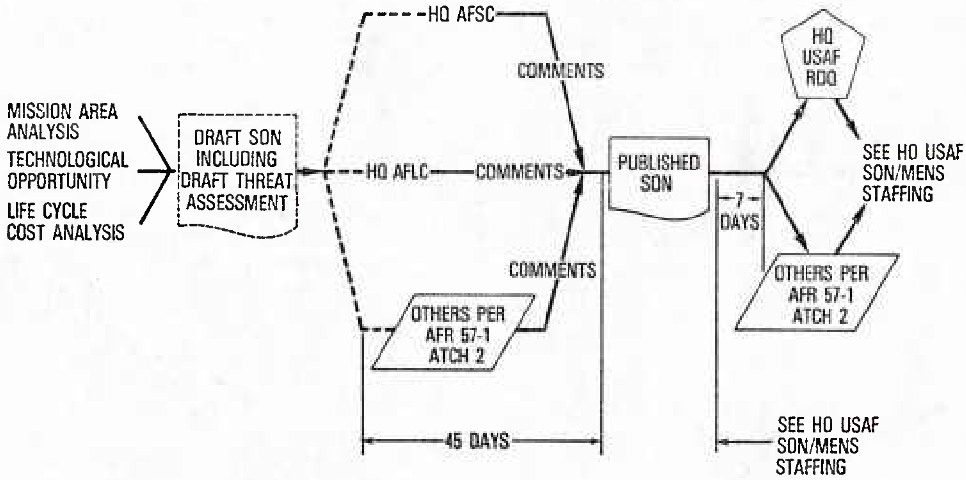

Figure 1. Operational Requirements Process - SON Development and Distribution

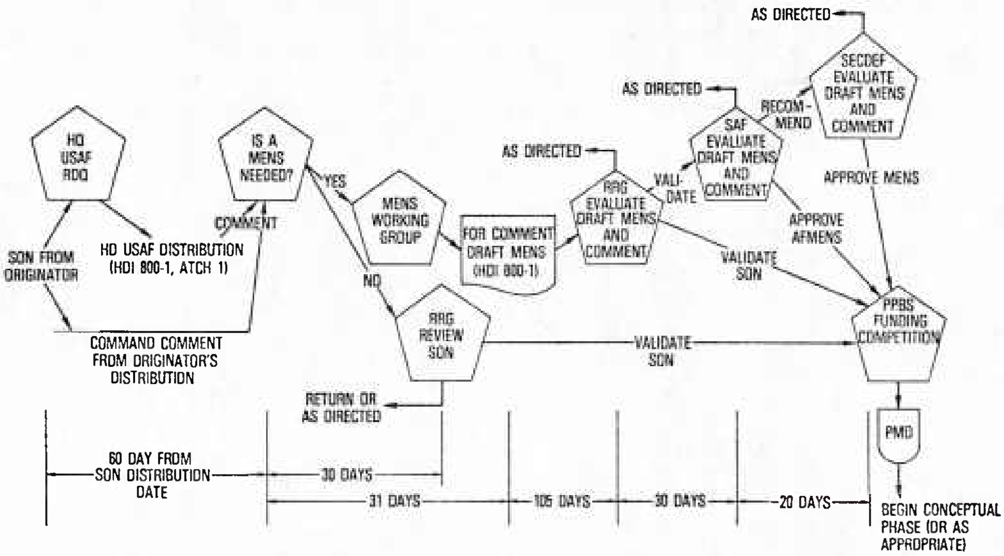

Figure 2. Operational Requirements Process - Hq USAF SON/MENS Staffing

The processing of the published SON by Hq Air Force involves a second review by various sister commands including again the potential developer. At this point, AFR 57-1 requires Air Force Systems Command, which is primarily responsible for the development and acquisition of aerospace systems to accomplish the Air Force mission, to provide a program plan for the post-Milestone 0, Concept Exploration, phase and to identify technical uncertainties.

Assuming that the program required to satisfy the need qualifies as a major program, Hq Air Force then drafts a Mission Element Need Statement (MENS). (10) A schedule for the drafting, review and processing of the MENS is suggested in AFR 57-1. (Figure 2) While the schedule may be operative regarding the Air Force personnel, it has little effect on the Secretary of Defense who ultimately must approve the document. Until the MENS is approved, the clock has not started on the "birth time" of the program; Milestone 0 has not been reached.

Clearly, therefore, while OMB Circular A-109 may not affect the period from Milestone 0 to Milestone II, the start of FSD, there is a good possibility that its implementation, which within the Air Force requires a lengthy decision process, may adversely impact the period from perception of the need by the operator to the start of FSD. What then can the product division, that element of the Air Force Systems Command responsible for the development and acquisition of the system to meet the validated need, do to alleviate this possibility?

THE ROLE OF THE PRODUCT DIVISION

The product division's functions prior to Milestone 0 are currently not fully specified in AFR 57-1. During the need identification stage, primary responsibility for the MAA rests with the operating command, while the product division is indicated to have a collaborating role wherein they support the operating commands with both technical and costing analysis. The product division also assists the originator in writing the SON, when requested, and provides comments on the draft SON. The operator who originated the draft SON determines the content of the final document. (11)

During the need evaluation stage, the product division provides comments on the SON through the Systems Command to Hq Air Force regarding: feasibility of alternative solutions; impact of providing a solution; development, acquisition, and installation planning estimates; and a program plan for the conceptual phase activities. Additionally, during this stage, the product division may be called upon to comment on the draft MENS. (12)

What then should the product division do in addition to these specified pre-Milestone 0 tasks which may reduce the program "birth time"? The answer lies in the consideration of the relationship of the product division to the major system acquisition process.

The recently revised DoDD 5000.1 indicates that in addition to the MENS, a Secretary of Defense Decision Memorandum (SDDM) is required at Milestone 0. With the SDDM, the Secretary:

> ". . . documents each milestone decision, establishes program goals and thresholds, reaffirms established needs and program objectives, authorizes exceptions to acquisition policy (when appropriate), and provides the direction and guidance to OSD, OJCS, and the DoD component for the next phase of acquisition." (13)

The product division which has the ultimate responsibility for the acquisition, has a keen interest in the SDDM, for it defines the cost, schedule, and performance goals and thresholds; and more importantly, the parameters of the acquisition strategy which it must implement.

Indeed, the product division which represents the technical and managerial data base on a major system acquisition program, may well be considered to have a fundamental responsibility to ensure that an informed Milestone 0 decision is made. Having day-to-day experience procuring, managing, and technically directing comparable major systems, this product division represents the principal data base from which the program risk, and other factors, may be assessed. Program risk, the probability that the system will not be delivered within cost, on schedule, and to specification, must be considered at the inception of the program to facilitate informed decisions regarding such aspects as affordability, availability and capability. (14) As is indicated in the current DoDI 5000.2,

> The validity of decisions reached at each milestone depends upon the quality of cost, schedule, performance, and supportability estimates presented at the milestone reviews. Although there is considerable uncertainty early in the acquisition process, every effort must be made to use the best available data and techniques in developing estimates. (15)

The "best available data" for the Milestone 0 estimates should be with the responsible product division. It then is a matter of marshalling the data and applying the proper techniques to develop credible estimates and plans for the Concept Exploration Phase.

The second aspect of the SDDM, regarding which the product division should be assumed to have fundamental responsibility, is acquisition strategy. While the acquisition strategy for the entire program cannot be established at Milestone 0, the SDDM can significantly reduce the length and complexity of the Concept Exploration Phase, and correspondingly the program front-end, through limiting the alternative concept solutions

considered to those which most reasonably address the mission need or, if applicable, to a single concept. This is clearly within the prerogative of the agency head under 5000.1. (16) The product division, due to its experience with various system design concepts and knowledge of the technology base, is the most qualified to provide a preliminary assessment of the range and feasibility of alternative design concepts.

In addition to fundamental responsibilities to ensure that an informed Milestone 0 decision is made, the product division must be prepared to respond promptly to the Phase 0, Concept Exploration, direction. A primary means for a product division to marshall the relevant data and to prepare for Phase 0, is through a "mission analysis" activity. During a mission analysis ". . . the interplay of threat, capability, operation concepts, survivability, and other factors . . . which bear on the . . ." mission, is anlayzed. (17) The resultant data, in addition to facilitating an informed decision, serves as a basis for preparing a request for proposal (RFP) soliciting alternative system design concepts. This Phase 0 RFP is to ". . . outline the need in mission terms, schedule objectives and constraints, system cost objectives, and operating and deployment constraints. . . " (18) The ability of the product division to articulate the need "in mission terms," is highly dependent on an in-depth understanding of the mission from which the need arises. The conducting of a mission analysis contributes significantly to this understanding.

CONCLUSION

The Air Force Systems Command product division's unique role within the major system acquisition process enables it to contribute significantly to the pre-Milestone 0 decision process. Moreover, its active participation in this decision process enables it to respond in a timely manner, to the program direction provided in, and precipitated by, the SDDM. This participation, which clearly is within the DoDI 5000.2 definition of mission analysis, is an essential bridge between the perception of the need and the conceptual phase of the acquisition process. When properly implemented by the product division, this mission analysis function has a reasonable possibility of shortening program birth time.

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(3) Roberts, Dean E., "OMB Circular A-109 Impact on New Development and Leveling Effect," Eighth Annual DoD/FAI Acquisition Research Symposium, p. 297. (1979).

(4) "Procurement Policy Causes Struggles," Aviation Week and Space Technology, pp. 36-37, November 26, 1979.

(5) Defense Science Board 1977 Summer Study, "Report of the Acquisition Cycle Task Force," March 15, 1978, p. 11.

(6) Ibid.

(7) DSB 1977 Summer Study, p. vii; also see: AW & ST, p. 37, November 26, 1979; Martinez, Angie G., "Shortening the Acquisition Cycle"; Eighth Annual DoD/FAI Acquisition Research Symposium, p. 251.

(8) AFR 57-1, Statement of Operational Need (SON), 12 June 1979.

(9) AFR 57-1, paragraph 4.

(10) DoDD 5000.1, March 19, 1980, specifies, at para D.2.c, a number of criteria to be considered by the Secretary of Defense in making a decision to designate any system as major, however, unlike the preceding version, no funding levels are specified. DoD Instruction 5000.2, March 19, 1980, requires a MENS for ". . . each acquisition, including system modifications and additional procurements of existing systems, which the DoD Component anticipates will cost in excess of $100 million (FY 1980 dollars) in Research, Development, Test and Evaluation (RDT&E) funds or $500 million (FY 1980 dollars) in production funds . . .", para C.3.a.(1).

(11) AFR 57-1, para 4.

(12) AFR 57-1, para 6 and attachment 3.

(13) DoDD 5000.1, March 19, 1980, para D.4.c.

(14) See generally, "Final Report of the USAF Academy Risk Analysis Study Team," dated 1 August 1971.

(15) DoDI 5000.2, para E.5.c.

(16) Supra, note 13.

(17) Supra, note 1.

(18) DoDI 5000.2, para E.6.a.

PRODUCT ASSURANCE

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MANAGERIAL ANALYSIS SYSTEM FOR MANUFACTURING AND QUALITY ASSURANCE (MASMAQA)

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ABSTRACT

The military is highly dependent upon the private industrial sector to produce the capital equipment necessary to satisfy national defense needs. The weapons acquisition process is among the most sophisticated, complex capital investment processes in government or industry. Compared to other concerns, i.e., the acquisition process itself and weapon system effectiveness, a smaller proportion of attention has been directed toward improved understanding of the industrial processes and management systems that produce weapons. Yet, this vitally needed equipment is the output of private sector industrial processes and highly dependent upon effective and efficient management of two key elements--manufacturing and quality assurance. This paper posits a managerial analysis system for manufacturing and quality assurance (MASMAQA) which will improve our understanding of this industrial process and provide a framework for making key program decisions. MASMAQA is presented from the perspective of the program office. It recognizes the uniqueness of the defense aerospace market, a responsibility hierarchy that exists in the market, and the limitations of industrial management resources within the Air Force.

PROBLEM

Short of nationalization or a centralized market sectorial planning as proposed by Gansler (14;15), the individual program office needs to make key strategic, operational, and tactical decisions regarding the structure and performance of the program relative to manufacturing and quality assurance concerns on a decentralized basis. The dependence upon the industrial sector dictates that the framework for these decision processes be compatible with industrial concerns. The uniqueness of the market environment is a necessary prologue for setting forth the framework.

ENVIRONMENT

Military and civilian members of military program management teams and supervising staffs within the management chain of command are generally recognized as possessing high proportion of advanced degrees. Many have taken production manangement courses in their studies, but few of these courses truly prepared them for two aspects of their responsibilities - an understanding of the defense aerospace market and the translation of production/industrial management theories and concepts from functional management roles to one of managing a national resource, the defense industrial base. Product decision examples in textbooks range from appliances to TV sets. The queing model is a car wash. Make or Buy decision examples are $9.00 parts. Quality control is a sampling problem with operating characteristic curves. Plant layout involves little red wagon examples. Scale-up, translation, and application problems are left for the few astute to pick-up "on-the-job." Industrial management in the defense aerospace market is rarely discussed in texts or courses at the graduate level.

Capital Investment. A discussion of the formal structure of the weapons acquisition process, in which both government and industry jointly operate, is beyond the scope of this paper. However, two main aspects from the process are relevant. The process model with the phases (concept, validation, full-scale development, and production) and the milestones (DSARC 0, I, II, and III) are analogous to "textbook" models for: capital budgeting, return on investment, and new product development models. The other aspect is that as the weapon system progresses through the process and successfully passes each DSARC, more and more sunk costs accrue. The application of the Pareto Rule indicates that with the movement through each phase the program manager has decreasing ability to change the vital few system parameters effecting the cost of the investment (4;5;17).

The nature of this process places a heavy burden on the manufacturing and quality assurance function to assure that the system is manufactured in the most effective and efficient manner to required quality standards. The acquisition management process for military capital equipment is operable within a market that few have attempted to define in the context of traditional industrial management texts.

Market Structure. The defense aerospace market can be generally characterized as: (a) being production dependent, but having relatively small production quantities with relatively high per unit prices; (b) having uncertainty in demand

composed of both internal and external forces; (c) having a general absence of competition; (d) being fundamentally cost based; and (e) being pressured with high level external or public demands for visibility and accountability which result in an accompanying high degree of interaction (formally and informally) between customer and supplier (17;18).

Dependence upon a production program is characteristic of most firms and markets and is generally assumed in most production management texts and articles (6). What is generally missing is a treatise on industrial management for aerospace market products of small quantity production volumes, less than 1000 units, with high per unit prices, over $X,000,000 per copy. Although the military defines the quantity needed, Congress may "cut-the-budget" and reduce or stretch out programs (demand uncertaintv). Production models to treat this phenomena are limited (20;21). Configuration of aerospace production articles are subject to many in-line and retrofit design changes (an example of internal uncertainty). Scientific advancements in other areas may make current program technology obsolete and dictate program cancellations (external uncertainty). The effect and management of this disruption is rarely treated (17;18). Program management personnel are expected to assimilate this understanding through experience or they trust the judgment of their industrial counterparts.

Although competition among corporate entities is severe during early phases of the weapons acquisition process, the level and type of competition is not of the nature assumed in most industrial management and marketing texts. Note: see the paper, "Competition in Department of Defense Acquisition" by Martin and Golden, also in these proceedings.

Early phase competition in the aerospace market is generally characterized as vying for technical supremacy at or near the government's budgetary limit for research and development. Following the product development decision (DSARC II), however, there is a general lack of substitute products and alternative sources of supply. Production management texts rarely address management concepts of cost control, schedule, and quality in this monopolistic market. The generally assumed forces in the market that the "normal" customer can depend upon to keep cost, schedule, and quality in control, especially in the short range, is lacking in the aerospace market. Possibly long range market forces, i.e., the ability to win the next competition, are operable. Once again industrial management personnel on the government program management team are faced with translating theories and concepts generally operable within a competitive market to concepts and strategies that can be used to monitor and manage a monopolistic supplier.

In the long run all markets are cost based: cost of operation and profits need to be recovered. However, the preponderence of standard durable goods are sold on a competitive price basis. Short range prices in the competitive market create internal pressures within the firm to control costs and quality. However, in the defense aerospace market, price is negotiated and cost of operation is paid as long as the elements of cost are allowable, allocable (the government's fair share), and reasonable in accordance with Defense Acquisition Regulation (DAR) Section 15.

Since defense contracts, generally speaking, define what is to be built, how it is to be built, how it is to be managed, and government policies to be enforced; the program management team is at a disadvantage at any attempted initiative to challenge reasonableness. There are no substitute products for price comparisons, the contractors apply resources to comply with the contract requirement, accounting records show the costs that were incurred, and government management policies embodied in the contract cannot be eliminated. Again the industrial management member of the government program management team is left to his own devices to apply whatever effective industrial management concepts are deemed "appropriate."

The only industry that has been the object of more public (press, congress, and executive agency) inquiry into internal management processes than the defense aerospace market has been energy. On a national level, recently the petroleum industry has been exposed and dissected publicly in an attempt to gain an understanding of pricing policies and supply issues. Utility companies, regulated monopolies, petition state utility commissions for allowable rates. However, in neither of these situations, has the pervasive demand to disclose internal operations of an industry been as great as the pressures upon Department of Defense (DOD) program managers and the private sector of the defense aerospace market.

This public demand for information as well as the urgency by which managers and staff within the DOD pursue control to assure program success leads to a high degree of both formal and informal interaction between counterparts of both supplier and customer. Much of this interaction is more adversarial than cooperative. This situation is confusing to the "middle man," the program management office. The program office wants to assure success of the vitally needed system; consequently, program managers need to engage in a cooperative team effort with their industrial counterpart. They need to assure control so they, in an adversary role, demand "status" information to demonstrate that the program is in control. Both government and industry are dependent upon congress for funding.

In this case should program management personnel present a view to congress that "we" are managing the program at arms length or "working jointly" with the contractor to meet all program success criteria? This facet of the market environment, if not unique, certainly is not present in many market situations.

The defense aerospace market is dependent upon the effective functioning of the industrial or production process and is taken for granted by both management and educators. However, several interactive factors uniquely define the defense aerospace market out of the mold usually assumed in the educational and experience process. The capital investment process (the weapon acquisition process) is highly regularized and public. Programs operable within the market have small limited production quantities of high-dollar value. A large portion of their life cycle operates in a non-competitive, i.e., bilateral monopolistic market. High uncertainty levels are pervasive. There is a propensity to be cost based even in the short run. External pressures create confusing and shifting roles for the participants. If not unique, the defense aerospace market certainly is the exception which receives very little emphasis in the normal educational process and the literature. A participant apparently learns the environment by osmosis and experience because, at this time, no other teacher exists.

Responsibility Hierarchy. Another facet of the environment rarely addressed in the literature, and thus learned by experience, is the responsibility hierarchy for key participants. This responsibility hierarchy is presented graphically in Figure 1.

Breadth of Concerns

Participants	Focus	Finance	Schedule
System Program Office (SPO)	One Program	Program Budget	Program Schedule
Contract Administration Office (CAO)	Defense Contracts	Contractual Limitations	Contract
Contractor	All Customers :Now :Future	Departmental Budgets	Department or Station

Figure 1. Responsibility Hierarchy

The frame of reference and normal limits of concern of the SPO is the "program." The program is the reason for its existence. It exists to "control" the program and facilitate communication (up, down, or sideways) concerning the program. The SPO "lives" with the program budget and the program schedule. It generally has no concerns but the program.

The CAO organizational mechanisms, unique to the DOD, are primarily concerned with assuring contractor compliance with all defense contracts being performed by the contractor. The program contract may be one of many under the surveillance by the CAO. This contributes to the divergence of priorities between CAO and SPO (16). The frame of reference for the CAO is "What does the contract say?" However, particularly in the case of the Air Force Plant Representative Office (AFPRO), they are required to evaluate the effectiveness of the contractor's management systems. The CAO is, or should be, a primary source of information and understanding of contractor management and contract performance. Effective working relationships between SPO and CAO lead to facilitating translation between SPO and contractor (23).

The contractor is concerned with both present and future customers. This over simplification is not intended to belittle concern or responsiveness with performance on the contract or the program, and there may well be subtle differences between the two. The intent is to indicate that the contractor is not constrained by contract but directs focus to assure customer satisfaction in both short and long-run time periods. Generally speaking, both financial and schedule controls are focused at departmental or smaller units. Contractors, for a variety of "practical" reasons, transform program and contract tasks and resources into management responsibility units.

These three levels in the hierarchy have needs to array information for decision making in different ways.

To say the SPO has the narrowest focus of concerns and fewest variables is not to say the SPO job is easy. Rather, it infers that, since the SPO concerns are complex, the concerns of the CAO and the contractor are more complex. The competition for information in differing "formats" creates tension and conflict among all levels (13). If in the industrial management arena, manufacturing and quality assurance in particular, the SPO operated from a framework of informational needs somewhat compatible with those of the CAO and contractor these conflicts could be minimized.

Industrial Management Expertise. Especially since the Korean conflict, program management emphasis has been on technological excellence and operational effectiveness. Several initiatives over the past ten years have been taken to provide more emphasis on industrial management of programs (7;8;11). Many SPO's now have separate manufacturing chiefs. Production

Readiness Reviews are required (1;3;5). There are military standards for production management and work measurement. Quality '77 and Quality Horizons management studies have provided much needed attention (10;11). Nonconforming Material and Control of Subcontractor Quality Military Standards are now in use and product assurance concerns are receiving high level attention. We seem to have gotten the attention of industry's experienced and tenured industrial managers; however, the question is do we have the internal expertise to interact effectively.

Substantive reaction requires that we respond with meaningful depth and penetrating avenues of inquiry and then follow through. Our internal civilian base has dwindled, the military tours in manufacturing and quality are usually transient, and industrial management expertise is presently dependent upon a "regulatory requirement" base. Lacking formal text material for aerospace industrial management and a large internal workforce, it appears that meaningful experiences need to be documented in a useable reference system. This would facilitate concentration on the vital few critical decision variables versus many trivial considerations that consume resources and time.

Time pressures. Traditional activities differentiated by the time horizons from longest to shortest are: forecasting, planning, scheduling, dispatching, and expediting or follow-up. With the external demands placed upon program managers to prepare for major milestones (DSARC I, II, and III); internal milestones (Preliminary Design Review, Critical Design Review, and Physical Configuration Audit); monthly program reviews (Program Assessment Reviews, Command Assessment Reviews, and Selected Acquisition Reports); and reporting on what went wrong and why, the limited cadre of SPO manufacturing and quality assurance personnel are often relegated to the active roles of dispatching and expediting versus forecasting, planning, and scheduling.

Environmental Summary. A heavy burden rests with SPO manufacturing and quality assurance personnel to positively contribute to program decisions. There is a need to concentrate early on the vital few program parameters which can be adjusted to improve manufacturing and quality effectiveness and efficiency. The critical challenge is to create pressures essentially equivalent to those of competition in order to realize cost, schedule, and quality objectives. There are constant demands to account for program performance publicly which require a responsive information base from a diverse hierarchy of participants. A limited few Air Force industrial management personnel need to counteract continuing pressures for expediting type actions and status data.

PROPOSED SYSTEM

Manufacturing and quality assurance need to perform a specialized role in a unique market with limited tools. The managerial analysis system for manufacturing and quality assurance we propose as a macro-tool will make maximum utility of the limited micro-tools available to us today.

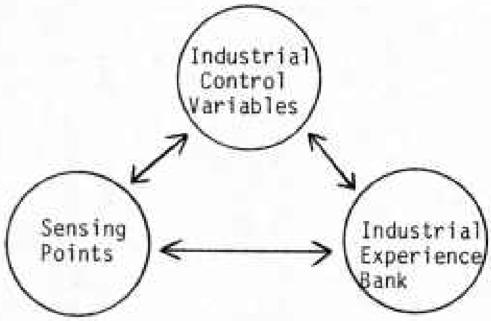

Figure 2

Managerial Analysis System for Manufacturing and Quality Assurance (MASMAQA)

The system as posited is composed of Industrial Control Variables, Sensing Points, and an Industrial Experience Bank. (Figure 2) The Industrial Control Variables contain commonly accepted industrial management parameters used by both industry, the academic community, and Air Force evaluation devices. (Figure 3) These control variables, expanded into decision areas and decision parameters and depicted in Figures 4 through 8, are a composite of classical, i.e., "textbook," regulatory, and experienced concerns.

Industrial Control Variables	Decision Area
Product (Figure 4)	Engineering/Design Methods and Processes Tooling and Test Equipment
Facility (Figure 5)	Facilities and Equipment Plant layout Planning
Management (Figure 6)	Make or Buy Operations Materiel
Cost (Figure 7)	Manpower Dollars
Control (Figure 8)	Quality Production

Figure 3. Industrial Control Variables

Decision Area	Decision Parameter
Engineering/Design	Completeness of Product Description Design Stablility Degree of Standardization Producibility Inherent Quality and Reliability Maintainability Risk Areas Subcontract Control
Methods and Processes	Process Qualification Producibility Studies Risk Areas Subcontract Control
Tooling and Test Equipment	Hard Versus Soft Commonality with Support Equipment Recurring Versus Non-Recurring Risk Areas Capacity (Build Plus Spares)

Figure 4. Product Industrial Control Variables

Decision Area	Decision Parameter
Facilities and Equipment	Capacity (Owned, Buy, Lease, Government Furnished) Modernization or Replacement Risk Areas Economic Justification
Plant Layout	Economic Flow Timely Flow Capacity Risk Areas
Planning	Master Schedule Leadtime Design Release Points (Product, Tooling, Material) Flexibility Risk Areas

Figure 5. Facility Industrial Control Variables

Decision Area	Decision Parameter
Make or Buy	Intracompany Transfer Policy Workload Sensitivity Economic Considerations Subcontracting Policy
Operations	Functional Interfaces and Decision Authority Program Coordination Corrective Action Management Customer Sensitivity
Material	Manufacturing and Quality Participation Economic Order Quantity Development Subcontractor, Supplier, Vendor Surveillance Critical Source Control Transportation and Handling Government Furnished Equipment

Figure 6
Management Industrial Control Variables

Decision Area	Decision Parameter
Manpower	Quantity Skills Labor/Management Relations Standards (Direct/Indirect)
Dollars	Budgeting and Estimating Direct/Indirect Facilities Tooling & Test Equipment Scrap, Rework Intracompany Transfers Efficiency

Figure 7. Cost Industrial Control Variables

Decision Area	Decision Parameter
Production	Information System Parameters Feedback (Planned Versus Actual) Facilities Utilization Schedule and Rate Material Information System Parameters Technical Data
Quality	Methods and Processes Tooling and Test Equipment Material Source Surveillance Inspection Corrective Action Risk Areas

Figure 8. Control Industrial Control Variables

It would not be unlike combining the Contractor Management System Evaluation Program (CMSEP) characteristics of the Air Force Contract Management Division (AFCMD) and the Manufacturing Management/Production Capability Review (MM/PCR) and Production Readiness Review (PRR) checklist questions used by program offices and the corporate model proposed by Skinner (6;21). Collectively industrial control variables provide the framework for communication among the various levels of the responsibility hierarchy not only for the current program, but for future programs and the industrial base itself.

This framework can be used for each of the sensing points in a program life cycle. It can be used for the pre-award survey (2) or manufacturing management/production capability review as currently applied. It would be updated for each of the program milestones and decision points, DSARC I, II, III, Preliminary Design Review (PDR); Critical Design Review (CDR), and PRR. It would provide the evaluation framework for the topics of expediting and special actions that manufacturing and quality assurance people find themselves involved with. Specific situations could be defined and resolved, much as they are now; however, each situation would be traced back to the affected decision area and control variables for evaluation of basic cause and corrective action.

Although problem prevention is the objective of any assurance system, problems will arise. The strategy for resolving problems once detected is important, especially in a complex aerospace program. Strategy formulation can be built from the answers to several fundamental questions: What decision area is out of control? Who is responsible for the decision area and control variable indicated? Are they aware it is out of control and do they accept the fact the out-of-control situation exists? Why is the decision area out of control? What alternatives have been identified to correct the condition? Have the "costs" for each alternative been identified? When will the corrective action be effective?

The latter question often is most important. Due to the "long pipeline" for many aerospace products, the "benefit" of corrective action will not be seen until the "production block" flows through the entire production system. To attempt forcing "premature" corrective action, that is corrective action on hardware beyond a critical control point, may consume unnecessary resources and aggrevate the condition. On the other hand, the problem may not be a true hardware problem (affecting program schedule, cost, or quality) but may be, instead, a variance to planning for which a minor paperwork adjustment will bring the program back in control.

The confirmation that a "problem" exists is also quite difficult. On the one hand, each layer within the responsibility hierarchy desires to demonstrate that either there is a problem they can resolve or there is not a problem. On the other hand, since timely delivery of satisfactory products is crucial to the national defense, the public nature of the program often requires a public accountability on the "alleged or real" conditions. Either situation requires equal application of skill and resources of program office manufacturing and quality assurance personnel to demonstrate they are "on top of the problem."

Due to the limited quantity of SPO industrial management personnel and their limited tenure (compared to their industry counterparts and the length and succession of programs), we propose the "findings" from each of the sensing points be placed in an Industrial Experience Bank. This industrially oriented memory bank would contain information gained on each contractor in the aerospace industrial base. It would provide access to information on each of the Industrial Management Control Variables and Decision Areas acquired from each of the sensing point activities. We recognize that over time the information will become "dated" and influenced by both past decisions and current conditions. However, a review of the Industrial Experience Bank would establish a baseline from which current conditions can be evaluated. We posit that such an Industrial Experience Bank maintained by the Air Force can greatly facilitate the focusing of current attention to key, recurring problem areas. By orienting the Industrial Experience Bank to the commonly accepted Industrial Management Control Variables, specific potential problem areas "lead time away" can be identified. It can provide a mechanism to shorten the learning lead time of program office industrial management personnel. It will also provide a means to rapidly learn the lesson of their predecessors from previous problems without being totally dependent upon their industry counterparts.

CONCLUSION

On an immediate and current program basis, MASMAQA can provide all industrial management personnel in each level of the hierarchy a common frame of reference for communication. It would use current missions, objectives, functions, and mechanisms of SPO, CAO, and contractor. On a longer range and broader basis, MASMAQA can facilitate effective utilization of limited government industrial management personnel and provides improved understanding of key participants in the defense aerospace market. In the long run it may even permit the identification of "reasonable" costs.

The public nature of the acquisition process used to develop and produce critically needed weapon systems require improved industrial management processes. Currently, management is forced to both manage ongoing programs and make these improvements without benefit of a formal

body of knowledge describing neither the unique market nor the industrial functions within the defense aerospace market. Weapon system development comes together in two places - "on the plant floor" and "as deployed" systems in the national defense posture. Our proposed Managerial Analysis System for Manufacturing and Quality Assurance (MASMAQA) can become the integrating strategy for addressing aerospace industrial management concerns of market efficiency, delivery effectiveness, and product quality.

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THE USE OF WARRANTY-GUARANTEE IN THE ACQUISITION OF GROUND ELECTRONIC EQUIPMENT

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ABSTRACT

This paper presents the results of a study to develop concepts and guidelines for applying warranty-guarantee plans to ground electronic equipment. The purpose of the guidelines is to assist program managers in selecting and properly evaluating candidate ground equipment acquisition programs so that warranty-guarantee plans can be structured, implemented, and effectively applied. Ground electronic equipment design, support, and maintenance characteristics that affect the application of warranty-guarantee are examined. Warranty plans are discussed for three maintenance levels: depot, field support, and on-equipment. Four types of guarantees are described: reliability, maintainability, availability, and cost. Criteria for the selection of specific plans are presented; these are based on equipment, operational, support, and economic factors. A life-cycle-cost model, used to compare warranty-guarantee costs against the organic support alternative, is discussed. Administrative and data requirements for effective program management are also described.

INTRODUCTION

Warranty-guarantee plans are currently being used within the DoD as a means of extending the contractor's responsibility for reliability and maintainability (R&M), performance, and cost into the field environment. The warranty-guarantee plans currently in use are based primarily on the characteristics of avionic equipments and on the conditions under which such equipments are operated and maintained. Because of fundamental differences in ground electronic equipments, such as design and R&M characteristics, deployment locations, and quantities, and in their maintenance and support concepts, alternative warranty-guarantee approaches are required.

A 1979 study sponsored by the Rome Air Development Center undertook to investigate and develop concepts and procedures for the use of warranty-guarantee in the acquisition of ground electronic equipment. This paper provides an overview of that study and the general scope of warranty-guarantee application. To establish a basis for subsequent discussion, the following definitions are provided:

- Warranty - a contractual obligation that provides incentives for the contractor to satisfy system field operational objectives of the user. The contractor is given an incentive, through a fixed-price commitment, to repair or replace equipment found to be defective during the period of warranty coverage.
- Guarantee - a commitment embodying contractual incentives, both positive and negative, for the achievement of specified field operational goals.

EXISTING WARRANTY-GUARANTEE PLANS

Table 1 highlights the principal features of the three basic types of warranty-guarantee plans that have been applied primarily to avionics equipments. The following paragraphs briefly describe these plans.

Reliability-Improvement Warranty (RIW). The RIW plan commits the contractor to perform stipulated depot-type repair services for a fixed operating time, calendar time, or both, at a fixed price. While the major expenditures of a warranty procurement are for the repair services involved, the primary objectives are to secure reliability improvement and reduce support costs. The question of whether the contractor can provide depot repair services at a cost lower than that of military repair is secondary to the objective of reliability achievement.

MTBF Guarantee. The MTBF guarantee requires the contractor to guarantee that a stated mean time between failures (MTBF) will be experienced by the equipment in the operating environment. If the guaranteed level is not met, the contractor is typically required to institute corrective action and to provide consignment spares until the MTBF improves.

The MTBF guarantee is normally procured in association with an RIW. An RIW plan provides incentive for MTBF achievement through the contractor maintenance support commitment. The MTBF guarantee provides an even stronger incentive because the contractor is obligated to provide consignment spares to relieve pipeline shortages that may result from low MTBF. The MTBF plan also includes requirements for improving the MTBF to stated values. The added risk the contractor takes in providing this guarantee will be reflected in his bid price. The procurement organization must then determine if the protection provided is cost-effective in relation to the price.

Logistic Support Cost Commitment. The logistic support cost (LSC) commitment is another means of controlling an equipment's operational effectiveness.

Table 1. FEATURES OF CURRENT WARRANTY-GUARANTEE PLANS			
Features	RIW	RIW/MTBF	LSC
Objective	Secure reliability improvement/ reduce support costs.	Achieve stated reliability requirements/ reduce support costs.	Achieve stated logistic support cost goal.
Method	Contractor repairs or replaces all applicable items that fail during coverage period; implements no-cost ECPs to improve reliability.	Same as RIW; in addition, contractor provides additional spare units to maintain logistic pipeline when MTBF goals are not met.	Normal Air Force maintenance; operational test performed to assess LSC; penalty or corrective action required if goals are not achieved.
Pricing	Fixed price.	Fixed price.	Fixed price or limited cost sharing for correction of deficiencies.
Incentive	Contractor profits if repair costs are lower than expected because of improved R&M.	Similar to RIW, plus possible severe penalty for low MTBF.	Award fee if goal is bettered; penalties for poor cost performance.

Under this plan the contractor makes a contractual commitment regarding a specified LSC parameter, which is quantified through an LSC model. A controlled operational field test is subsequently performed to acquire data for the key variables in the LSC model. The measured LSC parameter is then compared with the contractually specified or target value.

There is considerable variation among LSC commitment plans regarding the action taken as a result of the operational test. Most plans, in the event of achieving a lower measured LSC, provide for an award fee predicated on the amount by which the goal is underrun. In the event of an overrun, the plans provide for reducing or eliminating the award fee. In addition, some plans have required the contractor to take corrective action to achieve the stated goals or be penalized monetarily. In recognition of the risk inherent in this concept, the contractor bids a fixed price for undertaking a commitment where corrective action may be required. These types of plans are considered to fall under or are an adjunct to correction-of-deficiencies (COD) clauses. In the event the cost of correcting deficiencies exceeds the contractor's bid amount, provision may be made for Government and contractor cost sharing of the overrun up to some specified ceiling. Costs beyond the ceiling must be borne solely by the contractor.

GROUND EQUIPMENT FACTORS AFFECTING WARRANTY-GUARANTEE

Since existing warranty-guarantee plans were based primarily on characteristics of avionics equipment, a comparison was made between the ground and avionics areas for several different equipment factors. The results of this comparison are shown in Table 2. An expanded version of this table is provided in the reference together with a detailed explanation of the impact of the differences. Four of the most significant aspects of ground equipment are reviewed in the following subsections.

Procurement Quantity. While occasionally relatively high quantities of ground equipment are procured, in most cases the quantities are small in comparison with avionics equipment. These small quantities may result in relatively small contract dollar amounts and reduced competition. Small quantities also result in short production runs. The consequences are less opportunity to spread fixed costs and the possibility that the entire production run will be completed before the manufacturer receives sufficient operational data to learn of design or assembly problems. The major impact under the RIW concept is that there may be little or no opportunity to incorporate design or production line changes in the remaining items to be produced. However, for small quantities already delivered and in the inventory, it may be feasible to consider requirements for retrofitting the units to incorporate changes.

Equipment Transportability. For some items of ground equipment, transportability can be a serious problem. For example, the electronics unit of a long-range radar site weighs more than 450 pounds, while the heaviest unit in the avionics area usually weighs less than 50 pounds. Therefore, many end items of ground electronic equipment cannot be readily transported back to the manufacturer for repair under warranty. As a result, warranty may have to be applied at lower, more transportable levels, such as assemblies or subassemblies. Alternatively, the warranty may require the contractor to perform warranty repairs by traveling to the equipment site.

Reliability, Maintainability, and Availability Improvement. Ground electronic equipment in the inventory today ranges from 25-year-old tube-type equipment to the most modern solid-state technologies. In the newer items it is not unusual to encounter equipment for which reliability is quoted not as a mean time between failures in operating hours, but as a small number of failures per year. Therefore, for new equipment acquisitions, it may be unrealistic to expect large reliability growths.

Table 2. AVIONICS/GROUND EQUIPMENT COMPARISON			
Equipment Factors	Avionics	Ground	Impact* of Equipment Factors on Applying Warranty to Ground Equipment as Compared with Avionics
Procurement Responsibility	Relatively centralized	Fragmented	Less uniformity in application of acquisition techniques
Quantities Procured	Relatively high	Relatively low	Less opportunity to spread fixed costs, short production run, reduced competition if relatively low-dollar-amounts contract
Deployment	Significant quantities at individual bases	Small or even one of a kind at individual base	Proficiency of on-equipment maintenance technicians reduced
Wartime-Critical	Generally are	Many are not	Less dependence on military self-sufficiency
Mean Time Between Failures	Relatively low (100s of hours)	Relatively high (1000s of hours)	Less opportunity for improvement
Preventive Maintenance Inspections	Little to moderate use	Extensive use	Increase in induced failures
Redundant/Back-Up Equipment	Little to moderate use	Varies; more frequent use than avionics	Reduced impact of failure, with longer MTTR permitted
Maintenance Concepts/ Personnel	Mostly Air Force	Varies	Increase in options
Transportability	Relatively easy	Frequently difficult, especially without disassembly	Possible requirement for warranty services to be performed at equipment site, or warranty to be at a lower level of equipment that is transportable

*See narrative for additional explanation of impact.

However, even in cases where there is little potential for reliability growth, there may be potential for improving maintainability or availability. In some ground equipment applications, maintainability, in terms of maximum duration of downtime, may be more important than the actual number of times the equipment is down. For example, from an operational standpoint, in a long-range air defense radar it may be more advantageous for the equipment to be down five times per day, with a maximum downtime of 5 minutes, than to be down only once per day for a 20-minute period. On the other hand, in training applications it may be more important that the equipment be operationally available without any failures during an eight-hour training period. Because of the diversity in operational missions of ground equipment, a warranty or guarantee on maintainability or availability may be more productive than one on reliability.

Varied Maintenance Concepts. Maintenance concepts employed in the ground environment are extremely varied. For some ground equipment all on-site maintenance is performed by contractor personnel and failed assemblies or subassemblies are repaired contractually either on-site or at the contractor's facility. Some of these situations may lend themselves quite readily to warranty; others may not. For example, some sites will have a combination of Air Force and contractor maintenance technicians, with removed assemblies and subassemblies repaired at the organization, intermediate, or Government depot. Still other sites use Air Force maintenance technicians exclusively, and all failed assemblies are repaired at a Government depot. For any ground electronic equipment warranty being considered, this broad range of possible maintenance concepts must be taken into account. The following section addresses warranty plans based on the existing maintenance concepts.

WARRANTIES ON GROUND EQUIPMENT

Review of existing warranty plans and the ground equipment environment identifies warranty plans applicable at three different levels. These levels correspond to the traditional maintenance levels employed for Air Force ground electronic equipment. Thus the basic types are as follows:

- Depot Warranty
- Depot and Field Support Warranty
- Depot, Field Support, and On-Equipment Warranty

The characteristics of these warranties are shown in Table 3.

Table 3. WARRANTY CONCEPTS FOR TRADITIONAL MAINTENANCE LEVELS

Warranty Concept	Equipment Location	Responsibility, Timing, and Extent of Maintenance					
		On-Equipment Level		Off-Equipment Level		Depot Level	
		Timing	Agent	Extent	Agent	Extent	Agent
Depot	Local	Immediate	Air Force	Limited*	Air Force	Full	Contractor
	Remote	Delayed	Air Force	Limited*	Air Force	Full	Contractor
Depot and Field Support	Local	Immediate	Air Force	Full**	Contractor	Limited**	Contractor
	Remote	Delayed	Air Force	Full**	Contractor	Limited**	Contractor
Depot, Field, and On-Equipment	Local	Immediate	Contractor	Full**	Contractor	Limited**	Contractor
	Remote	Delayed	Contractor	Full**	Contractor	Limited**	Contractor

*Under the Depot Warranty, off-equipment maintenance by the Air Force would normally be limited to verifying that a failure had occurred.
**Under this warranty concept it is anticipated that the contractor would, to the extent possible, provide full maintenance services at the intermediate level. Units returned to the depot would be limited to those requiring special repair and test facilities or extensive failure analysis.

Under the Depot Warranty concept the Air Force provides on-equipment maintenance. The off-equipment, or intermediate-level maintenance is also performed by the Air Force but is normally limited to verifying that the equipment has failed. The contractor provides depot-level maintenance services under warranty on returned units. Under the second type, Depot and Field Support Warranty, the Air Force also performs on-equipment maintenance; however, all other maintenance is performed by the contractor under warranty. Field support is considered synonymous with intermediate-level maintenance. The distinction is that the support provided by the contractor under a Field Support Warranty replaces the maintenance that the Air Force normally performs at the intermediate level. It is anticipated that the contractor will provide maintenance services to the degree possible at the intermediate level and will limit units returned to the depot to those requiring specialized repair and test facilities or extensive failure analysis. In the third type of warranty plan the contractor is responsible for all maintenance at all levels.

The general logistics flow for the Depot and Field Support Warranty is presented in Figure 1. As indicated above, on-equipment maintenance is conducted by Air Force maintenance personnel, and the contractor provides intermediate-level maintenance for field support. He receives units removed from the equipment operating sites and, within a specified period, repairs the units and returns them to base supply. It is the contractor's responsibility to decide what will be repaired at the intermediate-level site and what will be returned to a central contractor facility comparable to a depot. Transportation costs will be an important factor in the contractor's decision.

Under each concept the manufacturer accepts the warranty under a fixed-price agreement. The agreement remains in effect for a stated calendar period or a prescribed operational time, or a combination of the two. The objective of each of these warranty concepts is to provide an economic incentive to the contractor to achieve acceptable performance in the field. The obligation to maintain the item under a fixed-price agreement provides the basic warranty incentive mechanism.

A variation to each of the three basic warranty types is made if the installed equipment is in a remote location and is operated without maintenance personnel in attendance. The high reliability of some modern ground electronic equipment may well make such remote operation and maintenance feasible in certain applications. Cost savings can thus be realized as a result of spares pooling and reduced manning. In this situation a maintenance team is dispatched from a central location to perform the on-equipment maintenance. The procedure is comparable to existing Mobile Depot Maintenance. The extended outage of failed equipment may be accommodated by redundant elements of the same equipment or by redundant equipment, or functional coverage may be provided by equipment located at other sites. In this circumstance, maintenance may be intentionally delayed from a few hours to a few weeks depending on the frequency of failure, the amount of redundancy, and the criticality of the system.

A more detailed explanation of the above-described warranties is provided in the reference. As noted therein, these concepts may be found to be cost-effective for many ground systems. In some cases recent trends in the reliability of electronic equipment could reduce the opportunity for reliability improvement. However, there may still be opportunity to improve equipment availability through maintainability improvements or to reduce manning requirements through effective use of contractor maintenance coupled with warranty. In addition, guarantees of various types may be a useful adjunct to a warranty program.

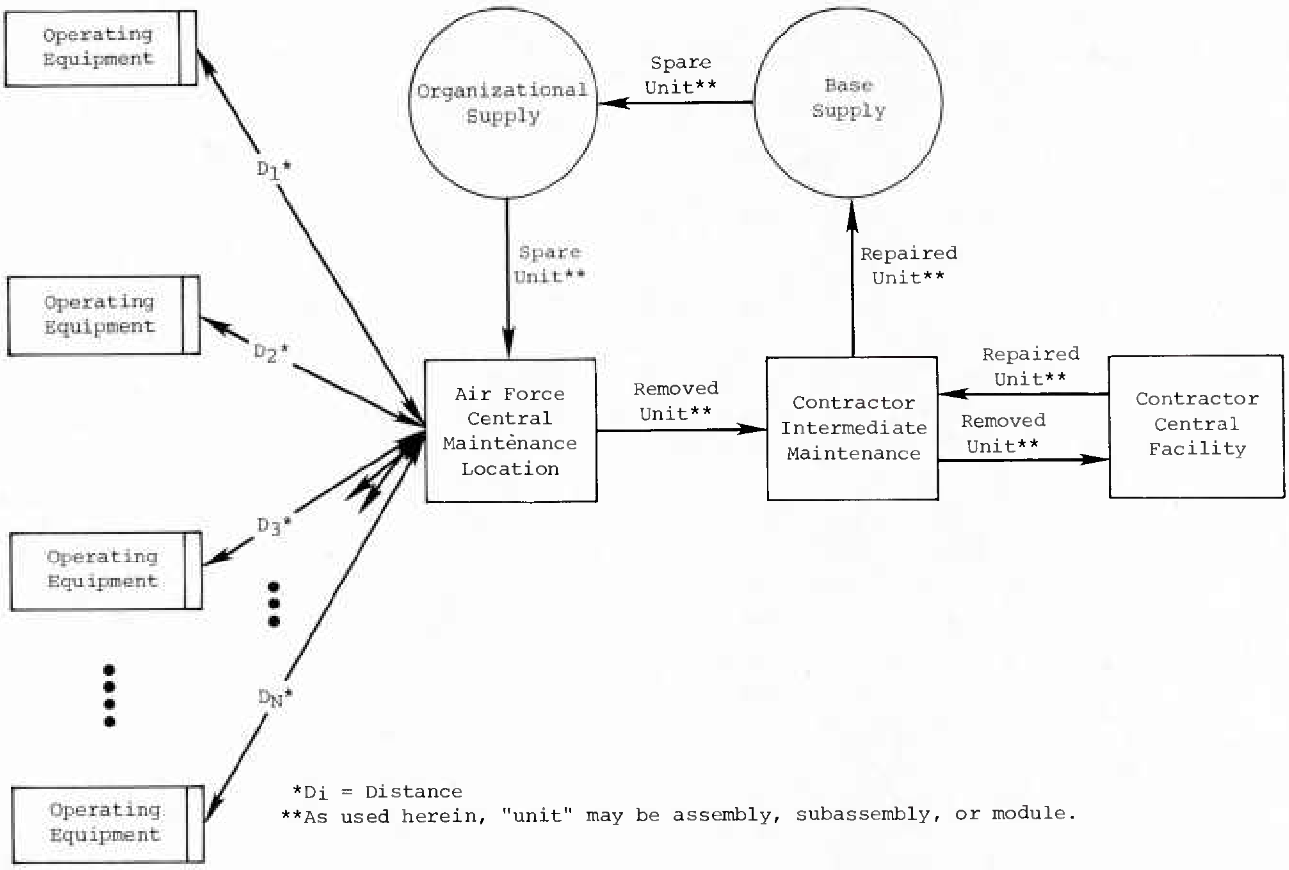

Figure 1. LOGISTICS FLOW: DEPOT AND FIELD SUPPORT WARRANTY

GUARANTEES ON GROUND EQUIPMENT

Guarantees (either as a "stand alone" contractor commitment or used in conjunction with a warranty) normally provide a stronger incentive to the contractor than a warranty alone. For example, under a warranty the corrective action usually required is to repair or replace units that fail during the warranty period. However, with a guarantee, various forms of remedy or compensation may be required if the guaranteed performance is not met. Depending on the type of guarantee, these can include (1) money in the form of contract price reduction or loss of award fee; (2) services in the form of engineering analysis or extension of the period of performance; or (3) material in the form of consignment spares, modification kits, or revisions to technical orders.

The following types of guarantees, with their overall objectives, are considered:

Type of Guarantee	Objective
Reliability	Control or reduce frequency of failure
Availability	Control or reduce equipment downtime
Maintainability	Control or reduce expenditure of corrective and preventive maintenance resources
Cost	Control or reduce the resources required to procure and operate a system

These guarantees, either as "stand alone" requirements or coupled with warranties, are described in Table 4, which shows that numerous combinations are possible. Comments are provided for each combination, together with possible remedies in the event the guarantee is not met. It should be noted that in these plans reliability is not necessarily the primary parameter of interest as is the case in the majority of existing warranty-guarantee applications. In the plans described in Table 4 it is recognized that recent trends in ground equipment reliability may reduce the opportunity for reliability improvement, but other needed improvements in maintainability and availability are also recognized. Maintenance and support costs and the operational availability of ground equipment are often determined in large part by the maintenance concepts, sparing levels, support equipment, and technical manuals provided by the equipment manufacturer.

Table 4. POSSIBLE WARRANTY-GUARANTEE PLANS*

Type of Warranty	Type of Guarantee				
	None	Reliability - MTBF	Availability	Maintainability	Logistic Support Cost
Depot	1. Contractor provides depot-level maintenance.	Same as 1, plus contractor guarantees MTBF. If guarantee is not met, contractor provides spares either outright or on a consignment basis. Mandatory retrofit of equipment may also be required.	Same as 1, plus guarantees availability in accordance with agreed-upon measurement method. If guarantee is not met, additional spares are provided at no cost to the Government or contract price is reduced. Mandatory retrofit of equipment may also be required.	Same as 1, plus on-equipment maintainability guaranteed in terms of mean time to repair, maximum downtime, or other parameter. If guarantee is not met, penalty could be monetary compensation, improved BITE, revised T.O. troubleshooting procedures, etc.	Same as 1, plus contractor guarantees that on-equipment and intermediate maintenance support cost will not exceed a guaranteed amount. If tests indicate cost is exceeded, either no award fee is paid or contract price is reduced.
Depot and Field Support	2. Contractor provides depot and intermediate or field support maintenance services under warranty.	Same as 2, with guarantee arrangement as stated above.	Same as 2, with guarantee arrangement as stated above.	Same as 2, with guarantee applicable to on-equipment maintenance. Could include maximum time to remove and replace subassemblies, maximum amount of preventive maintenance required, or maximum time to fault-locate.	Same as 2, with guarantee applicable to on-equipment maintenance only. Costs could pertain to training, on-site test equipment, etc.
Depot, Field, and On-Equipment	3. Contractor provides all maintenance. An exception could be to have Air Force provide preventive maintenance only.	Same as 3, with guarantee arrangement as stated above.	Same as 3, with contractor penalized monetarily if guaranteed value is not met.	Not applicable unless subsequent maintenance by Air Force is planned. In this case the contractor may be required to achieve stated maintainability parameter(s) before the maintenance responsibility transfer. If guarantee is not met, compensation could be monetary or no-cost ECPs to improve maintainability.	Not applicable.
None	Not applicable.	Air Force performs all maintenance. Contractor guarantees that production units will demonstrate a guaranteed MTBF. Additional no-cost-to Government spares provided if guarantee not met. No-cost ECPs, including retrofit requirements, could also be mandatory.	Air Force performs all maintenance. Contractor guarantees availability in accordance with agreed-upon measurement method. If guarantee is not met, the contractor could be penalized monetarily or required to determine reasons for noncompliance and institute corrective action.	Air Force performs all maintenance. Contractor guarantees maintainability in terms of one or more agreed-upon parameters. If guarantee is not met, contractor could be penalized or required to take corrective action such as redesigning BITE, revising T.O. troubleshooting procedures, etc.	Air Force performs all maintenance. Contractor guarantees maximum logistics support cost based on agreed-upon model and tests. If guarantee is not met, award fee may be withheld or corrective actions required.

*The intersection of a warranty line and a guarantee column indicates the combination of the two. For example, comments on a depot and field support warranty coupled with a maintainability guarantee are indicated at the intersection of the Depot and Field Support line with the Maintainability column.

Inadequacies in any of these areas can significantly increase costs or decrease field operational availability. The warranty-guarantee plans described herein provide a basis for assuring that maintainability, availability, and cost goals are met or, alternatively, provide appropriate remedies in the event these goals are not met. The reference addresses these remedies in more detail and indicates how a warranty and guarantee may be used together to provide complementary incentives.

Implementation requirements for each type of guarantee are also included.

WARRANTY-GUARANTEE APPLICATION CRITERIA

The proper development of warranty-guarantee provisions requires a great deal of effort on the Government's part to achieve procurement, administration, and logistics implementation. Thus the decision to include warranty-guarantee in a procurement should not be made lightly. To assist potential

users in discriminating between warranty-guarantee alternatives and in selecting an approach for a specific application, a number of application criteria have been developed. These criteria are listed in Table 5 in five areas: procurement, equipment, operational, support, and economic. The criteria are essentially qualitative and can indicate the general feasibility of a specific warranty-guarantee application.

The reference provides rationale for each of the criteria and an "importance factor," which assesses the relative importance of each criterion to each warranty-guarantee plan; however, each user of the table will have to determine the relative importance or applicability of the criteria for his intended use.

The final factor listed in the table, "Economic," is perhaps the most important. Unless sufficient maintenance activity is anticipated to justify its use, a warranty plan will become only a maintenance contract because of low incentives for R&M achievement. In addition, guarantee compliance will be judged on the basis of highly variable quantitative estimates, which may be challenged by a contractor if he is subjected to significant cost impacts. A complete analysis of warranty-guarantee potential, especially from the economic viewpoint, cannot be made until price and implementation proposals are received from the bidding contractors. The criteria listed in Table 5 must therefore be viewed as an initial means of screening to select those procurements for which the effort in developing warranty-guarantee clauses is believed to be worthwhile. The source-selection activity, coupled with an economic analysis, must be used for the final screening and decision on whether to implement warranty-guarantee provisions as part of the system acquisition.

ECONOMIC ANALYSIS

Economic analysis is performed to determine the financial feasibility of a warranty program. The evaluation consists of determining the expected life-cycle cost for the warranty alternative versus the cost expected to be incurred if the system were supported under normal organic maintenance. To perform the economic comparison, a life-cycle-cost (LCC) model is used. Such a model has been developed and formulated to represent the factors of concern related to the ground system environment. The analysis performed can more truly be represented as a comparative analysis since cost elements that are the same regardless of the approach -- e.g., installation cost, power -- are not considered as part of the analysis. The model for the warranty case computes the acquisition, spares, and preventive and corrective maintenance cost to be incurred by the Government, together with applicable AGE, training, and data costs. The warranty price can be inputted or can be estimated by the model. For normal organic support, the model computes the life-cycle cost, reflecting the designated maintenance concept. The model permits alternative concepts such as different maintenance concepts or warranty periods to be rapidly evaluated. Table 6 summarizes the cost categories considered, together with their applicability to organic and warranty LCC analyses. A detailed description of the model is contained in the reference. Warranty economic analysis may be performed at several points in the system life cycle. Table 7 summarizes the principal points of application. Subsequent paragraphs discuss the application in more detail.

<u>Validation/Full Scale Engineering Development</u>. Although warranty is applied during the production phase, planning for its use must begin as early as the validation or full-scale engineering development phases. At this point it is necessary to

Table 5. WARRANTY-GUARANTEE APPLICATION CRITERIA

Procurement Factors	Operational Factors
The procurement is to be on a fixed-price basis.	Use environment is known or predictable.
Multi-year funding for warranty-guarantee is available.	Equipment operational reliability and maintainability are predictable.
Warranty administration can be efficiently accomplished.	Equipment wartime or peacetime mission criticality is not of the highest level.
The procurement is competitive.	Operational failure and usage information can be supplied to the contractor.
Potential contractors have proven capability, experience, and cooperative attitude in providing warranty-guarantee commitments.	Backup warranty repair facilities are available.
An escalation clause is included in the contract that is applicable to warranty-guarantee costs.	Provision can be made for computing the equipment's MTBF.
The equipment will be in production over a substantial portion of the warranty-guarantee period.	**Support Factors**
Equipment Factors	Control of unauthorized maintenance can be exercised.
Equipment maturity is at an appropriate level.	Unit is field-testable.
Unit can be properly marked or labeled to signify existence of warranty-guarantee coverage.	Number of site maintenance personnel tends to be independent of equipment performance.
Unit operates independently of other subsystems.	Rapid restoral time is required.
Unit has high level of ruggedization when shipment is required.	Proper operation may be remotely sensed.
An elapsed-time indicator (ETI) can be installed on the equipment.	**Economic Factor**
Unit has no failure mode that would lead to additional damage to itself or other units if not corrected.	The combination of item reliability, maintainability, deployment schedule, and usage rate information is sufficient to determine compliance with the contract warranty-guarantee provisions and to suggest improvements if necessary.

Cost Category	Applicability*	
	Organic Maintenance	Warranty
Acquisition	X	X
Initial Spares	X	X
Replenishment Spares	X	X
Corrective Maintenance	X	X
Preventive Maintenance	X	X
AGE	X	L
AGE Support	X	L
Training	X	L
Data	X	L
Inventory Management	X	X
Warranty Price	-	X
Guarantee Value	-	X
Other	X	X

Table 6. WARRANTY COST CATEGORIES

*Codes: X = Applicable, L = Limited, - = Not Applicable.

Table 7. WARRANTY ECONOMIC ANALYSIS

Life-Cycle Phase	Purpose of Warranty Economic Analysis
Validation/Full Scale Engineering Development	• Determine economic feasibility of incentives • Evaluate various maintenance concepts and warranty plans • Evaluate alternate terms and conditions
Source Selection	• Evaluate economic advantage of incentive • Provide inputs to the decision for use of incentive • Provide inputs to source selection
Post-Production	• Evaluate warranty cost-effectiveness • Evaluate modifications to original warranty program • Acquire "lessons learned" for future programs

determine the basic economic feasibility of warranty or guarantee and to evaluate possible alternatives. Typically, during the early phases economic analyses can be made to determine the effect of various terms and conditions as they are being developed. If the terms and conditions are formulated at this stage, they can be included as part of the production RFP while there is still competition. In cases where competition ends at the validation phase, it may be necessary to use economic analyses to aid in making the final decision with respect to the use of the incentive concepts.

Production Source Selection. As noted, warranty applies to the production units; therefore, typically, the decision to obtain a warranty or guarantee must be made as part of the production source selection. The basic decision is concerned with determining if the warranty/guarantee cost being offered by the contractor is in the best economic interest of the Government. This is determined by comparing the LCC with warranty against the LCC for total organic support. The cost of a guarantee has to be compared with the expected protection to the Government that such a cost represents.

The final decision to use a warranty requires consideration of many factors together with the economics. Unfortunately, there is no precise formula that can be used to aid the decision. If the general application criteria raise no obstacles and there is a clear cost advantage for warranty, a positive decision for warranty usually follows. Conversely, the failure to meet several of the general criteria, combined with a cost disadvantage for warranty, leads to a negative decision. There remain a number of cases that may fall in the middle ground, and these will require careful consideration. Here it is often necessary to examine the sensitivity of the final cost value as input parameters change and to consider the level of confidence with which the inputs can be accepted. The computer-based warranty model permits such analysis to be performed rapidly, aiding the decision process.

Post-Production Award. Economic analysis can be made following production award, to evaluate the actual warranty performance against the LCC projections. It may also be used to evaluate any possible changes in the warranty program. For example, additional uses of the equipment may be identified following award. Another military service may decide that the equipment being procured will meet its requirements, or the equipment may be a likely candidate for foreign military sales. An analysis may be conducted to determine the economic impact of revised production quantities, changes in installation schedules, or revised operational usage. Analysis and documentation following production award would also be valuable in providing "lessons learned" for future programs.

WARRANTY-GUARANTEE PROVISIONS

A key ingredient in any successful warranty-guarantee program is the contract section that

contains the warranty-guarantee provisions. The provisions typically include the following three major parts:

Part I - Statement of Contractor Warranty-Guarantee

Part II - Contractor Obligations

Part III - Government Obligations

When a warranty-guarantee includes contractor maintenance at other than the depot level only, it may be necessary to prepare a separate statement of work (SOW) to describe the services to be performed. For example, at an operational site a contractor could provide warranty maintenance on equipment he had delivered; and on other Government-furnished equipment at the site, he could provide maintenance under a services contract. In these circumstances a separate SOW may be required. The reference provides specific language that may be used to construct provisions, and an outline for an accompanying SOW in the event it is required.

WARRANTY-GUARANTEE ADMINSTRATION

The success of a warranty-guarantee procurement will depend in part on proper Government management. Table 8 lists some of the major activities that should be accomplished for successful implementation of warranty-guarantee plans. Experience has shown that a critical factor is early coordination between the procuring organization, the logistics organization that will be managing the equipment after it is deployed, the DCAS organization that will be responsible for contract administration at the contractor's facility, and the using command(s). Experience gained by these organizations in implementing warranties over the past four to five years should pave the way for successful implementation of the plans introduced herein.

Table 8. MAJOR ACTIVITIES FOR IMPLEMENTING WARRANTY-GUARANTEE PROVISIONS

- Review contract provisions
- Verify using organizations and equipment deployment
- Review and update installation schedule
- Identify and monitor Air Force test and evaluation procedures
- Identify allowable Air Force maintenance actions
- Document failure-verification procedures
- Indoctrinate and train personnel
- Review contractor data plan

CONCLUSIONS

The following principal conclusions have been reached on the basis of this study:

- As compared with avionics equipments, which constitute the bulk of warranty experience to date, ground electronic equipments are very diverse in terms of equipment types and operational and maintenance scenarios.
- Diversity in ground electronic equipments requires that special consideration be given to many factors that have an impact on warranty planning and evaluation.
- In some cases recent trends in the reliability of ground equipment may reduce the opportunity for reliability improvement, but there may be opportunity to improve operational availability and to reduce maintenance and support costs.
- Several alternative warranty-guarantee plans are possible in the ground electronic equipment area; analysis is required to determine the most suitable, and the plans must be tailored to meet the special circumstances of individual procurements.
- Special circumstances (e.g., small quantities) often present in ground equipment procurements indicate that economic analysis is one of the most significant evaluation criteria. The economic model included in the reference provides a key tool for this analysis.

RECOMMENDATIONS

While the referenced study identified a number of unusual characteristics of ground electronic equipments, it also provided a range of possible warranty-guarantee plans which, depending on specific circumstances, can be effectively applied. The following recommendations are provided regarding the use of these guidelines:

- Adequate procurement lead time must be scheduled to permit warranty-guarantee planning and analysis.
- Warranty-guarantee provisions should be tailored to specific procurements and to the warranty-guarantee application.
- Since several of the plans developed herein are as yet untried in actual procurements, they should be exercised with care.
- The final decision to use any form of warranty-guarantee for the acquisition of ground electronic systems should be based on an economic analysis during the evaluation of contractor proposals.

REFERENCE

F. B. Crum, et al., "Warranty-Guarantee Application Guidelines for Air Force Ground Electronic Equipment," ARINC Research Corporation, RADC Report TR-79-287, August 1979.

MODELS FOR ANALYSIS OF WARRANTY POLICIES

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ABSTRACT

The purpose of this paper is to survey and, to some extent, compare a number of models that have been developed for analysis of warranty costs. Consumer, Commercial, and Military warranties are included in the study.

Consumer warranties include pro-rata, free-replacement, and combined warranties. The primary military warranty considered is the Reliability Improvement Warranty (RIW).

Warranty costs depend primarily on two elements: structure of the warranty and the life distribution of the items in question. Models differ as to how they deal with these elements. They may also differ depending upon whether the analyst considers the buyer's or seller's point of view (e.g. present value of future income) affect the structure of the models.

1. INTRODUCTION

In broad terms the purpose of a warranty is to establish liability in the event of premature failure of a product to perform its intended function. The intent is to specify who--buyer, seller, manufacturer, insurer, and so forth--is responsible for what and for how long. (In this context, the terms "warranty" and "guarantee" are considered to be synonymous).

Although they are perceived of quite differently by buyer and seller [2], both look upon warranties as a means of limiting liability. Within this framework, warranties serve a number of purposes. The buyer is protected in that faulty goods are replaced or repaired at a reasonable cost or no cost at all within some time-frame during which he could reasonably expect the item to perform properly. The producer and/or seller is protected in that warranty provisions may also specify consumer responsibilities, e.g., proper use of the product, prevention of damage, heeding warnings, proper choice of product for the use intended, and so forth. From a company point of view, warranties can also be an important element of marketing strategy. Here warranties are used as promotional devices in that the intent is to encourage purchase by reducing risk. The classical example of this is the five-year warranty offered at one time by Chrysler Corporation. (See [21] and [43]).

As a result of these diverse perceptions and purposes, there are wide variations in warranty policies among products, firms and industries. (Anderson [2] provides a number of illustrations of this diversity.) Thus a buyer often has a choice of warranties on competing products and a producer a choice among warranty policies. Analytical approaches to the resulting decision processes have led to the development of a number of models of the warranty process. The primary purpose of this paper is to present a survey of these models. The models are basically economic and statistical in nature--economic in that they deal with warranty costs, both to the buyer and producer; statistical in the sense that costs are a function of the life distribution of the item and decisions are often, of necessity, data-based.

In this paper we shall look first at warranty structures (terms, conditions, and so forth). Economic and statistical models will then be discussed in some detail.

2. WARRANTY POLICIES

2.1 Background. Historically, warranties are relatively recent devices, at least as far as common usage in transactions involving consumer goods is concerned. For millenia the dictum "caveat emptor" was, indeed, valid, at least as far as product reliability was concerned. On the other hand, it has long been recognized that the seller (or producer, etc.) is legally liable, under certain circumstances at least, for damage or injury.

For an interesting historical perspective on products liability, back to the seventeenth century, see [24]. See also the excellent review article by McKean [34]. There is, in fact, an enormous amount of material on warranties, products liability and related topics in both the legal and economics literature, most of which is beyond the scope of this paper. The interested reader will find these articles and the references cited a good introduction to these areas.

A related topic, public policy concerning warranties, has received considerable attention recently in both the technical and popular literature. At the forefront in analysis of public policy in this area is the Center for Policy Alternatives at M.I.T. (See [15], [29] and [4]].)

The most important recent legislation concerning warranties is the Magnuson-Moss Warranty Act of 1975. This act is discussed in several of the above references. It is concerned not only with terms of warranties, but even with the language in which they are written ("ordinary language," not "legalese"). It is, of course, the terms and conditions of a warranty, written and unwritten, that are the heart of the matter. We call all of this the warranty structure. It is discussed briefly in the next section.

2.2 Warranty Structures. A good overview of the operational and behavioral aspects of the warranty process, complete with flow charts, is given by Fisk [21]. Fisk developed stimulus-response models to represent the interaction between manufacturer, dealer, consumer, and government in the warranty process. Although the analysis is oriented specifically to the automobile and appliance industries, the models can readily be adapted for use in other applications.

We turn now to the warranty structure per se. Although there are probably as many kinds of warranties as there are writers of fine print, there are certain basic categories of structure that are recognizable. We begin with basic consumer warranties. The most important of these (in that they cover the vast majority of applications) are the following:

Free Replacement Warranty. Under a free-replacement warranty, the supplier provides the consumer, for a one-time fixed cost, as many items as necessary to yield service for the warranted service duration, say W. Replacement or repair of failed parts, systems, etc., is made by the seller free of charge, as often as necessary up to W time-units after purchase, after which any further repairs or replacements are the responsibility of the buyer. New-car warranties and many appliance warranties are basically of this type.

Pro-Rata Warranties. Under a pro-rata warranty, a failed item is replaced at pro-rated cost to the consumer. That is, if an item fails prior to the end of the warranty period, it is replaced at a fraction of the full price which is a function of the proportion of the warranty period experienced by the original item. The replacement is then warranted anew. This is the typical warranty offered on nonrepairable items, for example automobile batteries and tires. In essence, the pro-rata warranty is equivalent to a cash rebate to the customer since he is allowed a credit on the purchase of a new item. (See [35]). If the rebate is a 100% credit and the total warranty period is fixed (rather than begun anew when an item is replaced), the pro-rata reduces to the free replacement warranty. Terms of pro-rata warranties virtually always specify linear pro-ration although nonlinear regimes could theoretically be employed as well (Cf., [9].)

Combination Free-Replacement, Pro-Rata Warranties. Occasionally warranties embodying both of the above features are offered. The usual structure involves a free-replacement policy during an initial time period followed by replacement at pro-rata cost for the remainder of the warranty period (See [27]). Note that from an analytical point of view, this can be considered simply as a special form of the pro-rata warranty. Thus if the analysis of that is done in sufficient generality (including nonlinear as well as linear proration), the combination warranty will be dealt with as well.

As noted, most consumer warranties are of these types. The same is true of most commercial warranties. In the latter case, however, the terms are usually spelled out much more precisely because of the potentially large sums involved. In addition, commercial warranties are often of much longer duration than the typical consumer warranty [13]. As an example, ten year/30,000 flight-hour warranties on aircraft are reported in [8].

Reliability Improvement Warranties (RIW). A typical reliability improvement warranty is a complex warranty negotiated at the time of procurement of (usually) large, complex high-technology products. Terms usually include a guaranteed MTBF and require that the seller provide field maintenance of the equipment. The objective is to provide an incentive for the seller to improve the reliability of his product. Accordingly, fees paid are often tied to the MTBF ultimately attained (and demonstrated).

Note that a guaranteed MTBF is itself a warranty, differing somewhat from those discussed above in that it involves a collective warranty covering a number of items and/or replacements whereas the previous policies covered a single purchase. A related concept is that of a cumulative warranty, that is, a warranty covering the total service time of a number of items. This concept has evidently been considered in some types of procurements but, as far as we can tell, has not yet been addressed in the technical literature.

The RIW, originally called the Failure-Free Warranty, was introduced in 1966 in commercial aviation. It has since been used extensively by the military. (It was renamed RIW in 1973). Brief histories of the FFW/RIW are given in [31], [33], [40], and [41]. Detailed descriptions of RIW terms are given in [3], [26], and [42]. The role of guaranteed MTBF's in RIW procurements is discussed in [36] and [39]. Additional information, including many applications, is given in [30], [32], [13], [18], [7], [22], and [28].

3. MODELS OF THE WARRANTY PROCESS

In analyzing warranties, the primary concern of both buyer and seller is cost. Accordingly, most of the models of the warranty process that have been developed are, in essence, economic in nature. As is obvious from the above, the economics of warranties depends fundamentally upon two elements. These are the structure of the warranty and the life distribution of the items being sold under warranty. The models, therefore, reflect the warranty structure, at least implicitly, and are a function of some characteristic(s) of the life distribution. In addition, they may be oriented toward the buyer's or the seller's point of view or toward some balance between these two positions (that is, toward determination of an "indifference price"). In the ensuing discussion, we shall present a brief overview of some of the models that have been proposed for analyzing warranties. Although many considerations are common to both, we have organized our presentation into two parts--consumer warranties and commercial/military applications (i.e., RIW).

The notation that will be used in presenting the models is as follows: W = warranty period; W_i = length of ith phase of warranty for multi-phase policies (with $\Sigma W_i = W$); L = length of life cycle of the item: C = cost to the consumer, per item, for warrantied items (In most models this is simply the purchase price.); X = random lifetime of an item (assumed to be a nonnegative random variable); $F(.)$ = cumulative distribution function of X; $X_1, X_2, \ldots$ = lifetimes of successive items; C' = cost, to the consumer, of an unwarrantied item; π = expected profit; $\mu = E(X)$; $N = N(t)$ = number of replacements (or repairs, etc.), in the interval $[0,t]$; $M = M(t) = E[N(t)]$ (the renewal function); and $\mu_W = \int_0^W t\, f(t)dt$.

3.1 Models for Analysis of Consumer Warranties. Analyses of warranties have been reported in the technical literature only relatively recently. The first paper that dealt even remotely with the problem is [20]. The authors dealt with the problem of determining an optimal trade-off between price and quality for a firm. More recent papers have dealt with the analysis of warranties (equivalently, guarantees) per se. A straightforward model for assessing the value of a guarantee is given in [17]. The warranty analyzed is a combination free-replacement, pro-rata warranty, with free replacement until time W_1 after purchase and pro-rata from time W_1 until W_2. Exponential lifetimes are assumed and C is taken to be the average repair cost. W_3 is the useful life of a piece of equipment. The expected total cost is found to be

$$\frac{W_3 C}{\mu}\left[\frac{e^{-W_1/\mu} - e^{-W_2/\mu}}{\frac{1}{\mu}(W_2 - W_1)} - e^{-W_3/\mu}\right] \qquad (1)$$

If one has the necessary information, a comparison of this with the expected cost of an unwarrantied item, W_3C/μ, would enable one to determine the value of a warranty.

A considerably more general model, with special emphasis on the buyer's point of view (although buyer's, seller's and insurer's risks are considered), is given by Brown [14]. In Brown's analysis, it is assumed that the warranty period, W, and the amount of recovery upon failure of an item, R, are selected by the buyer, with the premium a function of these two quantities. Convex utility functions are assumed. Brown then provides a methodology for determining the optimal choices of R and W, discounting costs to the present. Some specific solutions, under somewhat restrictive conditions, are discussed. For example, it is found that under perfect competition, with costless transactions, a lifetime, money-back guarantee is not optimal.

A related analysis is given by Oi [37]. Oi's theory is that demand is a function of the price of a risky good and of the expected cost of damage. The consumer maximizes his utility by demanding a product that minimizes this total cost.

The above models are oriented primarily to the buyer's point of view. In [25] a model for analysis of the process from the seller's point of view is given. The objective is to maximize expected profit of a product sold under warranty. Expected profit per unit is calculated as $p(C,W) = C - [K + R\rho(W)]$, where C,K,R and W are as previously defined, $\rho(W)$ is the expected number of repairs during the warranty period, and $p(.,.)$ is expected profit per unit. The model also involves a demand curve, $d(.,.)$, which is taken to be a "displaced log-linear function," namely $d(C,W) = k_1 C^{-a}(W + k_2)^b$. Here, k_1, k_2, a and b are parameters which must be specified or estimated from data. Total expected profit, $\pi(.,.)$, is therefore

$$\pi(C,W) = k_1[C - (K + R\rho(W))]C^{-a}\,(W + k_2)^b.$$

Optimal values of C and W for maximizing total expected profit are found to be $C^* = a[K + R\rho(W^*)]/(a - 1)$ and $W^* = \frac{b}{a-1}\ \frac{K + R\rho(W^*)}{R\rho'(W^*)} - k_2$ where $\rho'(W^*) = \left.\frac{d\rho(W)}{dW}\right|_{W = W^*}$. As an illustration, the distribution of time between breakdowns was taken to be a gamma distribution, which leads to an explicit expression for $\rho(W)$ as a sum of Poisson probabilities. A program for solving iteratively to determine the optimal solution is discussed. Finally, a sensitivity analysis is performed. It is found that both W^* and C^* decrease as price elasticity (represented in the model by a) increases as C increases, and so forth.

Accounting aspects of warranty costs are considered in [1]. A general model for allocating costs as a function of demand is developed. Use of the

model requires knowledge of three functions, the demand function, the "benefits function" which describes the rebate policy, and the life distribution of the items under warranty, all as functions of time. The model includes nonrebate costs, discounting to present value and allowance for errors in validation of claims. Because of the broad generality of the model, it is difficult to envision the implication of the results in any specific situation. (A sensitivity analysis would be most useful here.)

Analyses of pro-rata and free-replacement warranty policies from both the buyer's and seller's points of view are given in [10] and [11]. The analyses assume nonrepairable items and have, as their primary objective, determination of an indifference price for each warranty policy and each party. The results are as follows: For the free-replacement warranty the price, C*, at which a customer would be indifferent between buying an item with or without a warranty is

$$C^* = \frac{\mu C'[1 + M(L)][1 + M(W)]}{\{\mu[1 + M(W)] + L\}} \tag{2}$$

For a pro-rata warranty, the price is

$$C^* = \frac{WC'[1 + M(L)]}{\{W + M(L)[\mu_W + W(1-F(W))]\}} \tag{3}$$

The interpretation here is that if the actual price of a warranted item exceeds C*, the customer is better off (given that he has such a choice) buying the item without warranty at price C' or less. If the price of a warranted item is less than C*, buy the item with warranty at that price rather than an unwarrantied item at C'.

From the seller's point of view, the indifference price is that which equates profit of warrantied versus unwarrantied items. Profit is $\pi = C - K[1 + M(W)]$ under free-replacement warranty and $\pi C[\mu_W + W(1-F(W))]/W - K$, under pro-rata warranty. The total expected profit can be obtained from these results. The indiffererence factors for selling-prices can then be obtained by substituting π for C' in the previous two expressions.

The authors also give modifications of the above expressions, discounting future costs and income to the present. In addition, methods for estimating these quantities, based on complete or incomplete data, are discussed. Some additional results on renewal functions of the type required in this analysis are given in [12].

Some of the most important recent analyses of consumer warranties, specifically appliance warranties, have been reported in [29] and [19]. (The former is a most comprehensive four-volume report.) The basic models (given in [38]) express total life-cycle cost to the consumer as a sum of five quantities: acquisition cost, cost of energy, service costs, disposal cost, and contractual cost (all except the first being discounted to the present). Specific data regarding each of these cost elements are given on six appliances. The authors conclude (p. 63) that their study "strongly suggests that the prices paid by consumers for warranties ... are high relative to the tangible value received."

In a more theoretical approach to the problem, Courville and Hausman [17] develop an economic model of warranties and a methodology for determining an optimum solution assuming that consumers select among product/warranty combinations in order to maximize their perceived utility. Risk averse and risk neutral buyers are analyzed and a "socially-optimal reliability level" is sought. The effects on the models of "warranty signalling" (excessive limitations on warranties being interpreted as indicative of low reliability) and "moral hazard" (warranty terms which make the consumer better off if he exercises the warranty provisions than if he does not) are also discussed. Again, the models are quite general in nature. The interested reader is referred to the reports for details.

3.2 Models for Analysis of Reliability Improvement Warranties. Under a Reliability Improvement Warranty the supplier agrees, as part of a fixed-price purchase contract, to repair or replace items that fail within a specified warranty period. To meet timeliness-of-replacement contract provisions, the supplier has to provide a pool or pools of spares and perhaps one or more repair facilities. The supplier, to minimize the attendant costs, will want to make the initial reliability of the item appropriately high and to make improvements as field use uncovers remediable faults. Supplier self-interest, if not contract provisions, may dictate that these improvements be made to all installed items. Additionally, reliability improvement may be encouraged, under certain RIW Contracts, by incentive payments for demonstrated increased MTBF or mean turn-around time. There may also be penalties associated with exceeding maximum turn-around time ceilings.

Mathematical models which attempt to describe or to optimize RIWs must capture their essential economic, operational and statistical features. These will vary by contract, by item, by use environment and doctrine, and by a host of other factors as well. They include manufacturing costs; profits; cost of spares and repairs; administrative costs; failure-, repair-, and pipline-time distributions; costs of making reliability improvements and their number; length of warranty period; incentive and penalty features; etc. A universal model, which could be specialized to each particular situation, might in principle be constructible. However, the literature with which we are familiar does not take this approach but deals with more-or-less specific combinations of features.

The lion's share of RIW studies appears to have been done at ARINC Research Corporation, Annapolis, MD by Balaban and his associates.

We attempt no complete coverage here of all existing RIW analyses. A brief description of a number of them follows.

Balaban and Retterer [6] developed equations for predicting the life cycle cost of an item with and without RIW (although this term was not then in vogue). These permitted examination of the relative economic advantages of warranty versus non-warranty purchases. For the no warranty case (denoted by the superscript "o"),

$$LCC^o_{T_W} = N^o C_p A_{T_W} + C^o_{MOD} + C^o_{DMU} + C^o_{ISU} A_{T_W} + C^o_{RSU} T_W \qquad (4)$$

where $LCC^o_{T_W}$ = life-cycle costs over $(0,T_W)$ for a no-warranty procurement; T_W = calendar time in months; N^o = number of units purchased; C_p = purchase price per unit; A_{T_W} = amortization factor for $(0,T_W) = T_W$/expected equipment life; C^o_{MOD} = expected amortized costs of reliability modification; C^o_{DMU} = direct user maintenance costs; C^o_{ISU} = initial support costs; and C^o_{RSU} = monthly recurring support costs. These factors are themselves modeled separately to reflect their stochastic nature. (See [5] for details.)

With warranty (denoted by superscript 1),

$$LCC^1_{T_W} = N^1 C_p A_{T_W} + \left[C^1_{MOD} + C^1_{DMC} \right] R(T_W)(1+P) + C^1_{DMU} + C^1_{RSU} T_W, \qquad (5)$$

where C^1_{DMC} = contractor direct warranty repair costs; $R(T_W)$ = risk factor contractor applies to costs for a warranty period of T_W months = $(1 + r)^{T_W}$, $(0 < r < 1)$; P = contractor's fee; and C^1_{MOD} = contractor costs for modification, discounted and amortized.

Using an illustrative example, the authors [6] concluded "that a properly constituted and applied warranty can yield signigicant reliability and life-cycle cost benefits..."

Balaban [3] suggests a "very simple model" for pricing a warranty: Warranty Price = [Fixed Costs + (Expected number of returns)(cost per return)] × (Profit Factor). He suggests various ways of formulating more complex models and notes that all models depend crucially on accurate prediction for MTBF, which itself may grow. He also gives the following expression for expected profit under an RIW:

$$P(\lambda_B) = A(\lambda_B)[C(\lambda_B)F - \int_0^\infty C(\lambda^*)dG_\lambda(\lambda^*)] - [1 - A(\lambda_B)]C_L - C_B \qquad (6)$$

where $P(\lambda_B)$ = profit if the RIW is bid at failure rate λ_B; λ = the average failure rate of the population of warranted equipment over the warranty period (λ is taken to be a random quantity); $G_\lambda(\lambda^*)$ = the prior distribution function for λ = $\text{Prob}(\lambda \leq \lambda^*)$; $C(\lambda)$ = total contractor warranty cost for failure rate λ; $A(\lambda_B)$ = the probability of contract award if the bid price is based on λ_B; F = profit factor applied to all bids; C_B = costs associated with the warranty proposal; and C_L = costs associated with losing the award (e.g., employee termination costs). Balaban works out an example and discusses how the contractor can control his risks.

In [23], profit equations under three types of RIWs, which are termed Basic RIW, RIW with Spares shipment guarantee, and RIW with MTBF Guarantee are given. "Under the Basic RIW the contractor is paid a fixed price to support his equipment for a fixed period of time commencing with the delivery of the first unit." A "simplified" profit model for the Basic RIW is

$$P = W - C_w - \frac{Q_T U t_w}{MTBF_a} C_r - I(MTBF_a) - D_t, \qquad (7)$$

where P = profit (loss); W = fixed price paid to the contractor for the warranty; C_w = contractor's fixed costs associated with the warranty; Q_T = total number of systems to be delivered; U = usage rate in operating time per calender time; t_w = duration of warranty period; $MTBF_a$ = achieved MTBF (average over the RIW period); C_r = contractor's cost per unit repaired; $I(MTBF_a)$ = cost of improvement actions to achieve $MTBF_a$; and D_t = damages for not meeting the turn-around time requirement.

In the RIW with Spares Shipment Guarantee, the contractor agrees to ship a spare within a specified time after a failure occurs. This replaces the turn-around time requirement of the Basic model. Damages are assessed if there is a stockout condition at the spare parts depot. A profit model for this situation is

$$P = W - C_f - \frac{Q_T U t_w}{MTBF_a} C_r - I(MTBF_a) - D_s, \qquad (8)$$

where D_s = (expected) damages for stockouts at the spare parts depot over the warranty period.

A formula for D_s based on Poisson probabilities is given.

Under the RIW with MTBF Guarantee, the contractor guarantees that his equipment will achieve specified MTBFs by specified points in time. If the contractor fails to meet the MTBF schedule, he must supply "consignment" spares according to an agreed-upon formula. A turn-around time ceiling, as in the basic RIW, is usually specified. Under this form of RIW, a profit model is

$$P = W - C_f - \frac{Q_T U t_w}{MTBF_a} C_r - I(MTBF_a) - C_s S_c - D_t, \tag{9}$$

where C_s = cost per consignment spare, and S_c = number of consignment spares required. A typical formula for S_c is

$$S_c = \left(\frac{MTBF_g}{MTBF_a} - 1\right) S_t, \tag{10}$$

where subscript g indicates that the item is guaranteed and S_t = target spares level. The paper concludes with a discussion of decision models for making a reliability improvement. An example is included. These decision models are extended in a later paper by the same authors [22].

A model for evaluating the economic incentive for a contractor operating under an RIW to implement an ECP (engineering change proposal) at no cost to the customer is given in [16]. The author assumes exponential failure time distributions and examines the cost savings achieved by reducing the failure rate for an identified failure mode. Other parametric analyses are performed as well.

Balaban and Meth [4] summarize the results of a DoD tri-service-sponsored study of contractor risks associated with RIWs. Risks are identified and approaches to reducing them are suggested. "The basic conclusion drawn from the study is that a military warranty can be structured to share risks equitably. Further, warranties provide proper incentives to reasonably assure that equipment reliability objectives will be met."

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QUALITY INCENTIVES AND THE GOVERNMENT'S ROLE IN PROCUREMENT
QUALITY ASSURANCE WITH THE RAPIDLY CHANGING TECHNOLOGY

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ABSTRACT

Quality of parts, assemblies, software and systems starts at the point of control of the individual characteristic. A series of these characteristics stack up to look like a gear, an airplane, data printouts or an automobile. Measurement of these characteristics at the point of control is far more significant and economical than is a lot by lot or an inspection after an accumulation of parts. Unacceptable parts or assemblies, delivered under the present inspection of statistical rules tend to decrease military readiness and give a false picture of stock ready for use. Costs for scrap, rework or reacquisition of replacements are non-productive. The so-called "cost effective" systems that deliver defects using AQLs must be re-examined to include defect replacement costs as part of the original formula for the acquisition, and incentives for quality must be given at the point of manufacture of the "characteristics" of the parts. Contract should require characteristic control more than lot by lot inspection.

DEVELOPMENT OF BEST LOCATION FOR INCENTIVES

Complex Systems. (Electronic or Mechanical) Experience in Quality Assurance financial incentives at the point of measurement or test in an AF Ballistic Missile program was a significant milestone. Hundreds of test points on a re-entry vehicle and its related ground support equipment were established. When the test was called a "test", every failure was counted. A log-log curve was established from experimental model failures. A failure rate was projected for the production quantities. Each failure was counted and eventually the contractor learned that a repeat failure was costly. He learned to immediately analyze each failure to fix production items heading for the same test point.

Figure 1 gives an indication of the dollars and goal established for the re-entry vehicle of a ballistic missile. It should be noted that the failure curve progressed nearly parallel to history until the impact of the importance of a failure indicating immediate cause determination was realized. As all production items in the line following were examined and corrected when the cause was discovered, repeat failures began to drop off and the failure curve dropped toward the

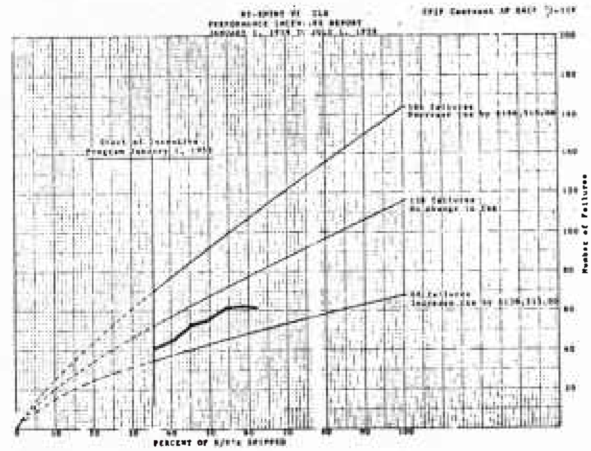

Figure 1. R/V Quality Incentive Report

incentive money.

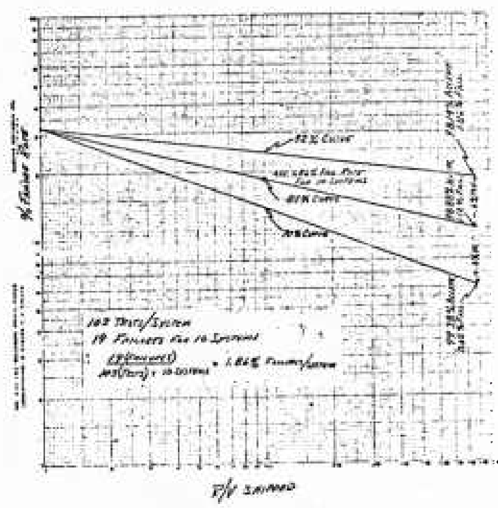

Figure 2. Ground Support Equipment QA Incentive Projection

Figure 2 was negotiated for the ground support items, such as R/V pre-launch monitor and electrical simulator as well as test sets for pre-launch monitor, simulator assembly and R/V vehicle. These were monitored separately and some loss of incentive money was caused because entry of major components being purchased created an unforeseen

problem entering into the system.

Care must be exercised to monitor such a program and since all the components are previously tested, the system is assembled. The covers are put on and it is delivered to test. No trial tests are allowed. All tests are for incentive and counted in the important column. This puts the burden on the person who builds, assembles, and delivers to test and these are the people who should be getting the incentives.

The Government's QA position must be at the test monitoring but more importantly in the contractor development of procedures to immediately determine failure causes and transmit information to the characteristic manufacturers (shop people) who correct the error at that level. Government QA programs must monitor the shop actions rather than lot by lot inspections.

The final items of this complex system were tested with no failures. The contractor had earned most of the bonus negotiated.

Assemblies and Components. (Electronic or Mechanical) As procurement drawings are studied, most of the characteristics cannot be verified or measured, productively, at the point of product acceptance. Defense Logistics Administration Manual 8200.1 reaches out to the point of control verification concept but the considerations of sample sizes, lot sizes, hold areas and toll gates must be de-emphasized, in order that the government QA person can concentrate on determining characteristic control points and verify that manufacturing people are indeed following the procedures that produced an acceptable first item.

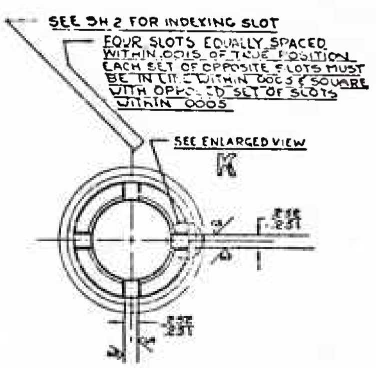

Figure 3. Detail Requirement of Rotor Blade Assembly

As an example, Figure 3 shows some important characteristics that must be controlled in order that the next assembly drawing (Figure 4) can be properly accomplished. Each assembly is accomplished one at a time. No lots are accumulated for characteristics of this type. The incentive, therefore, is at the point the operator performs and the government assurance must randomly verify that the shop procedures that assure the accomplishment of this precision result are followed.

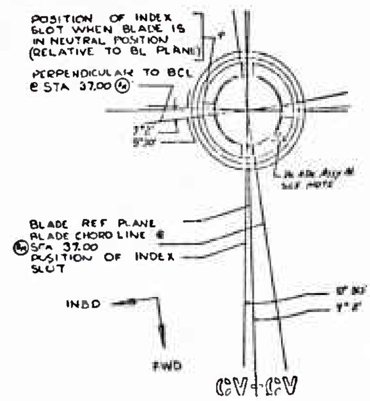

Figure 4. Assembly into which part (Figure 3) fits

Mechanical or Electronic Components. In the average statistical plan, the percent defective allowed will result in a piece or car or other product being shipped that is defective and the person or agency receiving the piece or car has a problem. The characteristics are controlled as they are manufactured. This inspection operation is a verification that the control was adequate. It is too late when the characteristics are stacked up so that they produce a defective part or inoperative auto.

The Defense Logistics Agency Quality Assurance Manual DLAM 8200.1 lead us to the IPI Section and the point of control of the characteristic. It could be a fixture, a drill, a milling cutter, an automatic machine or a procedure telling the operator what steps to take to control the manufacturing of the characteristic. This is the control point and where the financial incentives should be concentrated. Statistical measurements taken after this are redundant in that they measure AOQL. There would be no need for percent defectives because there would be no defectives.

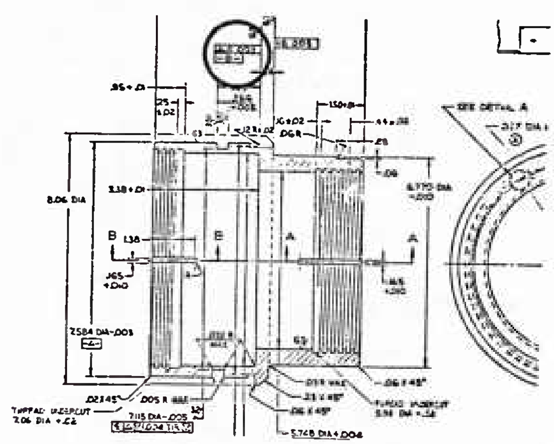

Figure 5. Part Maunfactured by Numerical Control

Figure 5 is a representation of a part manufactured as a spare. The dimensions circled are critical but not economically measurable at final inspection on a surfact plate using a sampling plan. The contractor has a shop procedure that requires the operator measure each of them with dial indicators prior to removing the part from the tape controlled machine. This is the point the incentive for the operator's performance plus the government verification on a random basis should take place. It is important that the production schedule and the government's representatives time should be carefully coordinated. (1)

In addition to the above, there is a program written for this part on the tape controlled machine used for the manufacture. The program is designed to provide the cutting of the thread with a single point tool as the last operation. As soon as the thread is cut, the program holds until a thread gage is applied. If more work is needed, it must be recut as once the machine releases the part, the timing cannot be picked up again. Here the quality is built in and here the incentive plus the government surveillance should take place. If the operator is following the procedure here, final inspection with thread gages can be eliminated.

Software and Computer Testing and Measuring

With the rapidly changing technology, most of this activity takes place at the push of a button.. There is no subsequent test. This technique delivers items directly to the customer with no other verification inspection or test. Although this is considered 100% inspection or test, the entire control of the quality is in the program written for the test. Programs must be written to accommodate redundant circuits, testing each one independently proving surge, temperature shock magnetic; low pressure or high pressure simulations must be provided; and the quality incentives must be considered at this point of control - the program.

```
37 MEASURE 15.9V AT -5MA MGRP CONN20 WAIT 10MS
   MTEST 4.8V RNEG MGRP
38 AOFF CONNX
39 IF TFAIL THEN PRINT 87150000-000  S/N(        ))
40 CHECK CONTINUITY FROM)
41 CONNECTOR PIN X TO)
42 CONNECTOR PIN 20,IF PRESENT)
43 THEN CHECK FOR SHORTS FROM)
44 THESE PINS TO ANY ADJACENT)
45 CLAO RUNS---THANK YOU---
```

Figure 6. Final Test Program (section)

Figure 6 is a randomly selected program for an aircraft electronic box. Note the program lines 37 through 45 - nothing in the way of instructions to the test equipment if convector pin 20 is not present or there are any shorts. Note also that line 39 requires printing a number if there is a failure.

```
39 IF TFAIL THEN PRINT 87150000-000  S/N(        ))
40 CHECK CR2 FOR TYPE AND)
41 INSERTION ACCURACY, IF)
42 OK,THEN VERIFY CONNECTION)
43 FROM CR2 CATHODE TO TP3)
44 (TP3=VCC OR +5 VOLTS).
```

Figure 7. Final Test Program

Figure 7 also gives no direction if connection line 42-43 is not okay plus no direction if voltage line is inaccurate.

The quality control here is not reading test data from the printout or watching the little green lights saying okay but it is in the program. The incentive for quality should be given here and it is here the governments's QA actions are significant.

GOVERNMENT QUALITY ASSURANCE

All government plans must include verification at points of control. This means that QA personnel must be able to read all test and inspection programs in the computer field. Personnel will also need to understand machine operation and manufacturing procedures to verify the various characteristics at the point of control rather than on a lot by lot statistical basis, allowing percent defective defects to be accepted.

Contracting efforts must concentrate on allowing bonuses or incentives at manufacturing control points. Individual contractor people, considering additional monetary recognition for producing defect free parts will take more interest in control prior to and at the time of manufacture.

Experience implementing this plan led to the discovery that the manufacturing people were pleased that someone was taking an interest in what they were doing and now realized their contribution to quality. In one instance, an employee was reprimanded for not following his procedure. The QA proceeded more carefully after that even though it was the contractor supervisor's function to assure the following of procedures.

We might compare military readiness to, for instance autos. Unless the dealer or sales agency is a part of the statistical sampling - the customer or user has no recourse. Our experience with autos is a prime example. If the manufacturer saves inspection money through statistics, they should readily, through dealers, fix the known defectives that the customers found in their 100% inspection. The purchaser who receives the "defect allowed" has great difficulty persuading a car dealer to accomplish the corrections that are assumed when the 100% inspection is done by the customer. In the case of the government agency receiving one of the defectives in the lot, the lone isolated user is the person having the difficulty. In the case of the government agency the depot stock area is not keyed in to the producer's statistics. AOQL lot verification may still not turn up the defect. The key is the

control and incentive at the point of manufacture of the characteristic.

Proper planning for this change in emphasis on control point incentive would include new looks at Government Quality Assurance Representatives. They must now coordinate their time with production schedules of contractor. Verification will not necessarily take place at the time of signing acceptance documents.

Management review teams will take a new look at the need to separate the Quality Assurance efforts into separate categories. The management of Quality Assurance will become more important than the management of information. Precise sample sizes, forcasted schedules of procedure evaluations, and specific information abour important characteristics verified or to be verified will not always be available on the myriad forms usually examined in reviews. This management of information or the limited ability of the Quality Assurance personnel to tell other what they did or plan to do on various forms must be reconsidered.

Contract documentation must be constantly changing to take advantage of the new technology presently developing and assist field personnel to maintain the professional image.

(1) Appreciate programming coordination provided by Mr. Jeffrey Snow, Cumberland Machining, New Britain, Connecticut.

QUALITY HORIZONS STUDY

Ira J. Epstein

Air Force Systems Command

ABSTRACT

Over the past several years, the Air Force Systems Command (AFSC) has experienced a significant reduction in its quality assurance workforce, while the workload has remained relatively level. Concurrently, significant advances have been achieved in aerospace technology. Also, several major and costly quality problems occurred in 1978 when Gen Slay took command of AFSC. These conditions caused Gen Slay to become concerned about the current approach to quality assurance. This approach, which primarily consists of an in-plant effort, had not changed to any great degree for almost 20 years. Gen Slay felt that it was necessary, as we enter the 1980s, to critically evaluate this approach and recommend changes to meet the anticipated challenges of advancing technology and diminishing resources. This paper summarizes the findings and several of the actions resulting from the study which are expected to enhance the quality of AFSC weapon systems in the operating environment.

STUDY APPROACH OVERVIEW

The Quality Horizons Study was established by Alton D. Slay, General, USAF, Commander, Air Force Systems Command, by correspondence dated 22 Nov 78. The study directive was based on a plan developed by the AFSC Quality Assurance Office and approved by James W. Stansberry, Major General, USAF, AFSC/Contracting and Manufacturing. The study approach contained four main points:

1. Examine the concepts of contractor responsibility for end item quality and reduced Government in-plant presence and how these concepts could be implemented, managed and enforced in AFSC based on experience in various government, commercial and foreign settings. Consider programs for certifying contractor quality assurance (QA) systems and personnel while assuring no degradation in end item quality.

2. Identify the type of contractual relationships which would provide strong positive or negative incentives that successfully place the responsibility for item quality with the contractor. Examine commercial practice for possible application in Air Force contracts.

3. Evaluate the qualifications of the AFSC QA workforce and changes required in recruitment, training, education and assignment to strengthen the future workforce.

4. Develop the proper QA organization structure and manning including the concept of a product assurance office, to implement changes resulting from the study.

It was assumed that there would be no increase in overall manpower that would result from recommendations contained in this study.

Col Bernard L. Weiss, Deputy for Contracting and Manufacturing, Aeronautical Systems Division, was selected as Study Director on 15 January 1979. The study team consisted of six personnel from various AFSC organizations with extensive experience in quality, reliability and contracting.

The team visited 66 government agencies and industrial firms in the United States, Japan, Germany, Denmark, Norway and Belgium. The industrial firms visited were engaged in work involving total commercial, total defense or a combination of the two. The government organizations visited included both DOD and civilian agencies. Each location visited was provided a briefing to describe the intent of the visit and the reason for the AFSC study. The organizations visited usually provided a briefing on their view of quality assurance, their organization, and recommendations with regard to the team's study objectives. Following this, the team conducted an in-depth interview, concentrating on those unique aspects of the organization visited and innovations they had implemented or suggested for consideration. The major areas of review were: quality planning, quality measurement, organization/manning, education/training and contracting techniques.

QUALITY PLANNING

Quality planning for commercial products begins by developing design criteria which is often published in company handbooks or procedures manuals which supplement industry standards. These efforts reflect experiences, lessons learned and proven techniques for assuring the inherent reliability and quality of the design. A significant aspect of this early involvement for design assurance is the use of a parts, materials and processes (PMP)

standardization and control program. The more complex and critical the product, the more disciplined the use of PMP tools and techniques such as derating, parts application review, etc. A rational application (tailoring) of these tools is used and is based on program requirements as needed to support a cost effective program and the business strategy approach selected.

One commercial firm was able to reduce the number of rejects during the manufacture of its product from twice per item to less than 10 rejections per 100 items manufactured. They did this by management demanding a disciplined approach to quality planning. For example, the parts count was significantly reduced; derating criteria used; parts, subassemblies and assemblies screened and tested at each level; and labor intensive operations automated.

AFSC organizations generally do not have as disciplined an approach to assuring design quality. One notable exception is the AFSC Space Division (SD) which relies on contracted support in this area. SD feels very strongly that an effective PMP standardization and control program contributes more to product reliability than any other factor. They contractually impose quality planning factors such as derating criteria, parts application reviews, critical item and baseline controls. Even then, their experience has shown that extensive monitoring and review of the contractor's efforts in these areas are required to prevent catastrophic problems. Through their close technical involvement with the contractors, they are able to minimize cost, schedule and performance impacts. SD's efforts in this area closely parallel the study team's observations of successful industrial firms producing comparably complex equipment. SD as well as many commercial firms have experienced serious quality and reliability problems when the application of these tools and techniques has been lax or omitted.

The other AFSC Product Divisions have not tended to impose these same contractual provisions, nor do they have the same expertise, e.g. parts engineers to develop or monitor their contractors' performance in these areas. Thus, they are forced to rely upon contractors to develop their own programs, design criteria, etcetera. Even then, the program offices and contract administration offices are limited in their ability to monitor the contractor's performance in achieving these goals (not requirements) due to lack of skilled manpower in these disciplines.

An often neglected quality planning function in AFSC has been the early involvement of quality engineers. Quality engineers influence design by assuring that the design accurately reflects the requirements, that lessons learned have been incorporated, that the design is repeatedly producible, and that meaningful inspections and tests are both possible and planned. Many companies, especially in Japan, perform these tasks and feel they provide a very cost effective defect prevention function.

Another important aspect in assuring the reliability and quality level of the product is to freeze the baseline when the design has been proven. After the baseline is established any changes can be completely analyzed or hardware retested to determine possible impacts on quality and reliability. During initial design analysis, contractors in the commercial sphere thoroughly evaluate vendor designs to determine the level of involvement and controls that will be needed to assure vendor performance. AFSC program offices often are not manned with sufficient or trained personnel to perform this effort.

In the commercial sector, firms tend to rely on evolutionary product improvements. Quantum changes generally occur only when technology advances have been proven. Product improvements are generally made to correct specific problems in the design or manufacturing processes, and the impact of these changes on reliability and quality are evaluated. Extensive preproduction testing is performed to assure that the design is producible and will perform as intended in the field environment.

Whenever specific product quality and reliability levels are required by the customer, verification testing is considered almost sacred. Only by such testing at all levels; i.e., part, subassembly, subsystem and system level, can a manufacturer have confidence that the design will perform as intended. They recognize that design is an iterative process and seldom if ever will they produce a perfect design the first time even though they incorporate all currently known techniques. Unexpected problems can occur and may not be detected until the item reaches service. Thus, every attempt is made to subject the design to the anticipated worst case stresses to promote test failures. These failures are then analyzed to determine the cause so that preventive actions such as redesign, derating, circuit protection, etc., can be taken. Successful commercial organizations have found that numerous field failures are the direct result of failing to perform these vital functions adequately. Therefore, the product does not enter production until the manufacturer is confident that it is suitable and reliable.

In contrast, because of operational requirements, AFSC tends to push state-of-the-art advances in many areas simultaneously. Not only does AFSC require and support significant advances in performance with each new product, but tries to use the most advanced technologies and materials in manufacturing these products. As a result of these simultaneous learning curves, problems not only in performance and producibility occur, but major deterrents to quality are introduced. First, failure modes are introduced by not having fully matured the manufacturing process or by not understanding the problems such a process introduces. Thus, these failure modes are not recognized until equipment starts failing in the field. Problems in perfecting these new techniques and materials cause schedule delays and cost impacts which often result in cancelling the preproduction testing

that could have identified these problems. The irony is that when these inherent problems are not identified and eliminated early, then the schedule and cost impacts tend to be even greater. Such schedule and cost impacts further encourage shortcuts and the introduction of even more problems, and the vicious circle continues. Thus, the more a new product advances technology and performance, the greater the need for the application of product assurance principles and techniques, yet the more likely they will not be used due to cost and schedule considerations.

Directly related to quality planning is accomplishment of the various program technical and management reviews. Those companies and government organizations that have been most successful have placed heavy emphasis on these efforts. Industry performs extensive analyses of their manufacturing capabilities to assure that these capabilities are compatible with the requirements. They strive to balance the inherent capabilities and requirements by either improving the capability or reducing the requirements to an achievable level to assure that risks have been minimized. Program management is kept apprised of the evaluation results from which they can make program decisions based on risk assessments. Although all AFSC programs have similar reviews, such as critical design and production readiness, they are often performed by untrained and inexperienced personnel and in an undisciplined manner.

As seen in the commercial sector, industry's overall emphasis in the design area is on early failure analysis and defect prevention. AFSC programs invariably end up in a defect detection mode. The only way to avoid this is by early involvement by skilled quality, reliability, parts, etc., personnel concerned with product assurance requirements that will satisfy user's needs. These people must assure that the proper tools and techniques have been effectively and efficiently tailored and incorporated into the contract. This effort and the subsequent monitoring of the contractor's performance requires an appropriate level of manning and funding. Failure to assure an adequate level of manning and proper training invariably results in a reactive mode of problem tracking rather than failure prevention.

QUALITY MEASUREMENT

Measurement of quality begins by determining the contractor's quality of design, his capability to produce the product as specified and the effectiveness of his quality assurance program to assure conformance. Industrial firms engaged in development of commercial products tend to concentrate on these functions with their suppliers, recognizing that a vendor's capability and expertise truly determine the end product quality, reliability, schedule adherence and product cost. Their evaluation of a vendor is an in-depth, in-plant analysis by a team of specialists skilled in this function. They evaluate the vendor's total capability for producing and controlling the product's conformance to the requirements. They also consider a vendor's past performance as a strong indication of how he will perform on future contracts. Industry tends to select the best performers even though they may not be the lowest in initial cost.

AFSC has tended to place more emphasis on the lowest cost proposal due to the potential for protests, although more emphasis is being placed on past performance criteria of late. AFSC evaluations of a contractor's capability, quality assurance system and quality management are often performed only by evaluating the contractor's Quality Assurance Program Plan during source selection. Often the leverage to incorporate needed changes to the contractor's system is lost because these problems are not detected while still in a competitive environment. This results from a failure to fully evaluate the actual system because of a lack of skilled personnel to perform the evaluation. After contract award, such changes are difficult to implement even though the contractor's system is obviously deficient and the change will result in improved quality and contractor efficiency.

Industry measurement of quality in the commercial market area is achieved in many ways. Vendor's rejection rates are tracked, i.e., incoming inspection, failures during assembly, costs of rejects, etc. They also measure the product's performance in the field (e.g., maintenance delays, aborts, in-flight shutdown, warranty returns, spares usage rates, etc.). These problems are not only analyzed for cause and failure trends, but they are also fed back to the vendor and corrective action is required.

Since commercial enterprises often assume responsibility for product quality in the field environments through warranties, customer expectations, or product liability, they develop whatever data system is required to fulfill these needs. Their data systems range from sampling surveys to complete traceability depending on product complexity and the information required to make management decisions.

In the commercial environment, industry makes extensive use of field technical representatives for data feedback. This is particularly true during the preproduction testing, field testing and early deployment stages so that accurate and timely feedback is available for product evaluations, improvements and accelerating of product maturity. AFSC has successfully used contractor technical representatives for this purpose in some instances. However, when the AF does not have contractor personnel perform this vital function, there is a definite deficiency in our normal data system and neither AFSC nor the contractor gets adequate failure data for use in determining timely or necessary corrective actions nor for reliability or quality measurements.

Industry management generally requires quality and reliability reports to be made to them in

great detail so that they are able to continually assess their company's and vendor's quality performance and make trade-off decisions based on risk and cost analyses.

Air Force managers are generally interested in hearing about quality only on an exception basis, i.e., whenever there is a quality problem that impacts cost, schedule or performance. Reliability tends to be of a little more interest in that higher headquarters requirements demand reporting this factor, but only with respect to whether the goals have been attained and seldom for program decisions.

ORGANIZATION/MANNING

Organizations for quality vary considerably as do organizational titles. Titles range from Quality Control to Quality Assurance to Product Assurance to Product Effectiveness to Systems Effectiveness and others. The organizations varied depending upon customer requirements, product line and responsibilities considered important by management. For example, if customer requirements include reliability, there would be a reliability organization, often integrated with the quality organization. As the product line becomes more sophisticated, there are more quality engineers, reliability engineers and other professionals in the organization. As product liability, product criticality, cost, warranty provisions and customer expectations increase, organizations for field support increase.

One U.S. firm, in direct competition with Japanese industry in a high technology product line, has been able to capture and maintain a significant share of the market. They attribute much of their success to the synergistic effect of combining the assurance disciplines at the top management level. Similar successes, based on similar organizations, were observed in other U.S. commercial firms. There appears to be a trend throughout industry and the Government toward combining many of the functional disciplines into the same organization to take advantage of their related influences on product quality and reliability. Those industrial firms and Government agencies organized in this way felt that it provided a much better utilization of resources since the same individual could perform several related tasks that were previously fragmented among different functional disciplines. They also felt it resulted in a program-oriented attitude rather than the compartmentalized thinking that the old fragmented organizational structure encouraged.

The study team observed that no two AFSC Product Division organizations are organized the same. In fact, there is not even any similarity between the HQ AFSC organization and that of the Product Divisions. Consequently, the assurance discipline organizations receive guidance from a variety of HQ AFSC staff offices. This fragmentation contributes to the lack of a strong voice in making program decisions and hinders the development of a unified product assurance position that would maximize program benefits.

In most industrial organizations, where top management felt quality was important, quality management reported directly to the top operating official. In U.S. defense contractor organizations, quality is independent of the manufacturing organization and reports directly to the top operating official.

In Government agencies visited in the United States, the quality organizations and their level in the overall organization also varied. In the Naval Material Command (NAVMAT), the special Deputy Chief of NAVMAT for Reliability, Maintainability and Quality is a GS-16 and reports directly to the NAVMAT Commander. Each of the Naval Systems Commands below NAVMAT has a quality organization. At that level, the organizations are not uniform. A matrix concept is utilized. There are several GS-15s in the various Naval Systems Commands quality organizations. There are over 7,200 personnel in the Navy's quality career program, of which 6,200 are in NAVMAT.

The Army has a strong and disciplined organization for quality. It is headed by a GS-16 who reports to the Commander of the Development and Readiness Command (DARCOM). Each subordinate product command has a product assurance organization for development and another for readiness, generally headed by a GS-15. The quality assurance workforce in DARCOM is over 5,600 people. They too, are matrix managed. DARCOM's product oriented Development Commands and Readiness Commands use the program manager concept like AFSC. There are, on the average, four to five quality assurance personnel assigned to each program office. The Chief of Quality Assurance in larger program offices is a GS-15. In smaller program offices, the position is generally a GS-14. Quality Assurance in DARCOM includes the reliability function. Quality is organized to assure/assess quality at all phases of the acquisition cycle including deployment.

NASA's Johnson Space Center (JSC) has a quality organization which includes reliability and safety. There are 365 personnel in this organization which include 199 contractor support personnel. The Director of Safety, Reliability and Quality Assurance is a GS-17 and reports directly to the JSC Director. JSC is also matrix managed.

DCAS is organized somewhat differently since their function is solely contract administration. The quality assurance organization has about 6,500 people. The Executive Director of Quality Assurance is a Rear Admiral with a GS-16 Deputy. Regional Quality Assurance Directors are Colonels or GS-15s.

In contrast, HQ AFSC has a small quality assurance staff of five professionals headed by a Lt Col. This staff is two organizational levels below the AFSC Commander. Most of the quality assurance personnel in AFSC are in the Air Force Contract Management Division (AFCMD). The quality assurance organization in AFCMD is headed by a Lt Col who reports directly to the Commander.

There are 1,184 quality personnel in AFCMD. The grade level of the Air Force Plant Representative Office (AFPRO) Quality Assurance Division Chiefs is GS-13 or GS-14. In all AFSC product divisions the quality organization is three levels below the Commander. Quality assurance manning authorized in the AFSC product divisions ranges from five to 29. Two of the product divisions are matrix managed. The typical grade of a quality assurance manager assigned to a major program office is a GS-12/Captain. Some program offices do not have full-time quality assurance personnel assigned. The top quality assurance individual in the product divisions is a GS-13 or GS-14.

There appears to be a direct correlation between the influence of the quality assurance organization on management/program decisions and the grade of the quality assurance individual and his level in the organization. In U.S. companies, quality considerations are voiced; however, the final decision is usually a matter of negotiation and trade-off between cost and schedule. In Europe, quality appeared to be more influential and would normally not be sacrificed for schedule considerations. In Japan, quality factors normally dominated management decisions. The Japanese often sacrifice schedule and cost to attain high quality.

Quality assurance in the Army and NASA have an independent and equal voice with other functional organizations in program decisions. In AFSC, the QA organizations are normally too low in the overall organization to be influential. Quality assurance has neither an equal nor independent voice in program decisions because of their low organizational placement.

Although the QA capability in AFSC product divisions has been increasing over the past two years, it is not at a level sufficient to ensure that acquisition strategies and requirements trade-offs which generate program quality risk are given appropriate consideration prior to program decisions. Contributing to this are a lack of resources - both numbers and capabilities, the organizational location, and program management attitudes towards quality assurance.

Figure 1 summarizes the organizational placement and grade levels of quality assurance organizations in the U.S. government agencies visited.

EDUCATION/TRAINING

U.S. industry generally provides work related technical training to their employees. Equipment and system training is also available. Training in management and supervisory disciplines is not as readily available. Career development training is rare. College tuition assistance programs are generally provided for white collar workers. Some companies are reluctant to provide extensive training due to high personnel turnover rates.

All types of training are generally available and required in Japanese industry. New employees generally received extensive training. One year of technical training is common with emphasis on quality assurance. All company employees normally receive some training in the quality discipline regardless of their position or functional assignment. Training in quality is also provided to top managers. Training in Japan is considered to be a normal and necessary part of doing business and a good investment. Life-time employment, common in large Japanese companies, is an incentive to provide training.

Training and training programs in the U.S. military services and agencies range from extensive to almost non-existent. AFSC falls into the latter category. The Defense Contract Administration Service (DCAS) has an extensive training program.

QUALITY ASSURANCE ORGANIZATION PLACEMENT

UNITED STATES	LEVELS REMOVED FROM TOP MANAGER	COMPARABLE GRADE
DCAS	ONE	REAR ADM
NASA/JSC	ONE	GS-17
ARMY	ONE	GS-16
NAVY	ONE	GS-16
CMD	ONE	LT COL
HQ AFSC	TWO	LT COL
PRODUCT DIVISIONS (STAFF)	THREE	LT COL/GS-14
SPOs (ADDITIONAL DUTY)	TWO TO FOUR	CAPT/GS-12

FIGURE 1

In addition to the training that is available from DOD schools, DCAS has two excellent quality assurance training programs. One is an individual certification program whereby quality assurance specialists are certified in one or more commodity areas. Not satisfied with the availability of courses from DOD schools, DCAS has developed an in-house capability to provide 37 courses on-site. Many of these courses were developed by DCAS. Qualified instructors are trained in each regional office and many sub-offices. In FY 78 alone, DCAS taught 432 in-house courses and trained 4,741 students. About 78% of all DCAS quality assurance specialists are certified in one or more commodity areas. The second DCAS training program is a formal intern program. This program provides a continual input of well qualified, motivated, high potential personnel to fill various quality assurance positions as they become vacant. The program is designed to output staff specialists, in-plant specialists, quality engineers and safety specialists. The intern program is three years in length and consists of both classroom and on-the-job training. The program costs about $57,000 per intern which includes salary, travel and moving expenses for the three years. DCAS inputs about 60 interns a year.

The Army has three quality assurance intern programs: one for quality assurance specialists, one for quality engineers and one for ammunition specialists. The Army's programs are the oldest in DOD. The Army graduates about 60 quality assurance specialists and quality engineers each year. These programs are also three years in length and consist of classroom and on-the-job rotational training. The specialists and engineering program classroom training is provided by the Army's own school, AMETA. These programs are similar to the DCAS program but tailored to the Army's needs.

The Navy also has a quality intern program. It is for quality engineers only. It, too, is three years in duration and consists of six months of classroom training and two and a half years of on-the-job training at several Navy activities. The Navy program is the newest of all the intern programs. They input about 25 engineers each year. The unique feature of this program is that most of the training effort is accomplished by contractors. NAVMAT developed training outlines tailored to their needs and contracted for course development, course materials and instructors.

AFSC has neither an intern program nor a formal training program. Quality assurance training in AFSC is obtained by requesting training allocations through the AFSC personnel office. Training spaces obtained this way are few and far between. The HQ AFSC Quality Assurance Office has been attempting to establish a quality engineering intern program for over a year. Lack of manpower spaces have frustrated this attempt. As a result there is very little quality assurance training in AFSC.

There is an AFSC intern program in the Contracting and Manufacturing organization known as Copper Cap. These intern spaces are restricted to contracting and manufacturing functions. Although quality assurance in AFSC is generally a part of the Contracting and Manufacturing organizations, no spaces have been allocated to quality assurance interns.

The educational level of workers in quality assurance organizations in industrial firms varies considerably. This variation is generally related to product complexity and criticality. The inspection workforce is generally comprised of technicians and mechanics. As complexity and criticality increase, quality engineers, reliability engineers, statisticians and other professionals are added to the quality organization. In U.S. commercial firms manufacturing sophisticated equipment, professionals make up as much as 25% of the quality assurance organization. In some U.S. firms producing defense or space hardware, professionals comprise as much as 40% of the quality assurance workforce. These firms are producing some of the most complex and sophisticated equipment in the world. The AFPRO quality assurance workforce is responsible for monitoring the efforts of the contractors' workforce and for assuring compliance with contract technical requirements. The AFPRO quality assurance workforce includes about 15% professionals. (24% of all AFCMD civilians have college degrees.) Some of the defense contractors felt that the difference in professionalism between the AFPRO workforce and their industrial counterparts contributes to the adversary relationship which often exists. They expressed concern that untrained AFPRO personnel are evaluating the efforts of their highly skilled and technical workforce. Figure 2 displays the percent of college graduates in the quality assurance workforce in the various activities and countries visited.

CONTRACTING APPROACHES

The Quality Horizons study team observed almost as many different "commercial practices" as commercial firms. Many of the different techniques appeared to be simply variations on a theme, however, and there are a number of observations that can be made and conclusions drawn.

First of all, commercial contracting arrangements are mostly firm fixed price and are negotiated before work commences, except for off-the-shelf items. Commercial firms use redeterminable contracts on occasion, where new development or a new product is involved, or even where quantities are uncertain making firm pricing difficult. But incentive arrangements in the commercial environment are the exception, not the rule, both in the United States and in the other countries visited by the Quality Horizons Team.

Commercial firms are able to deal firm fixed price even on relatively complex items for many reasons. Some of the most important are competition, vendor specification control, no "changes" clause, commercial pricing techniques, and the marketplace in general. They base their requirements on current technology, and take advantage of advances

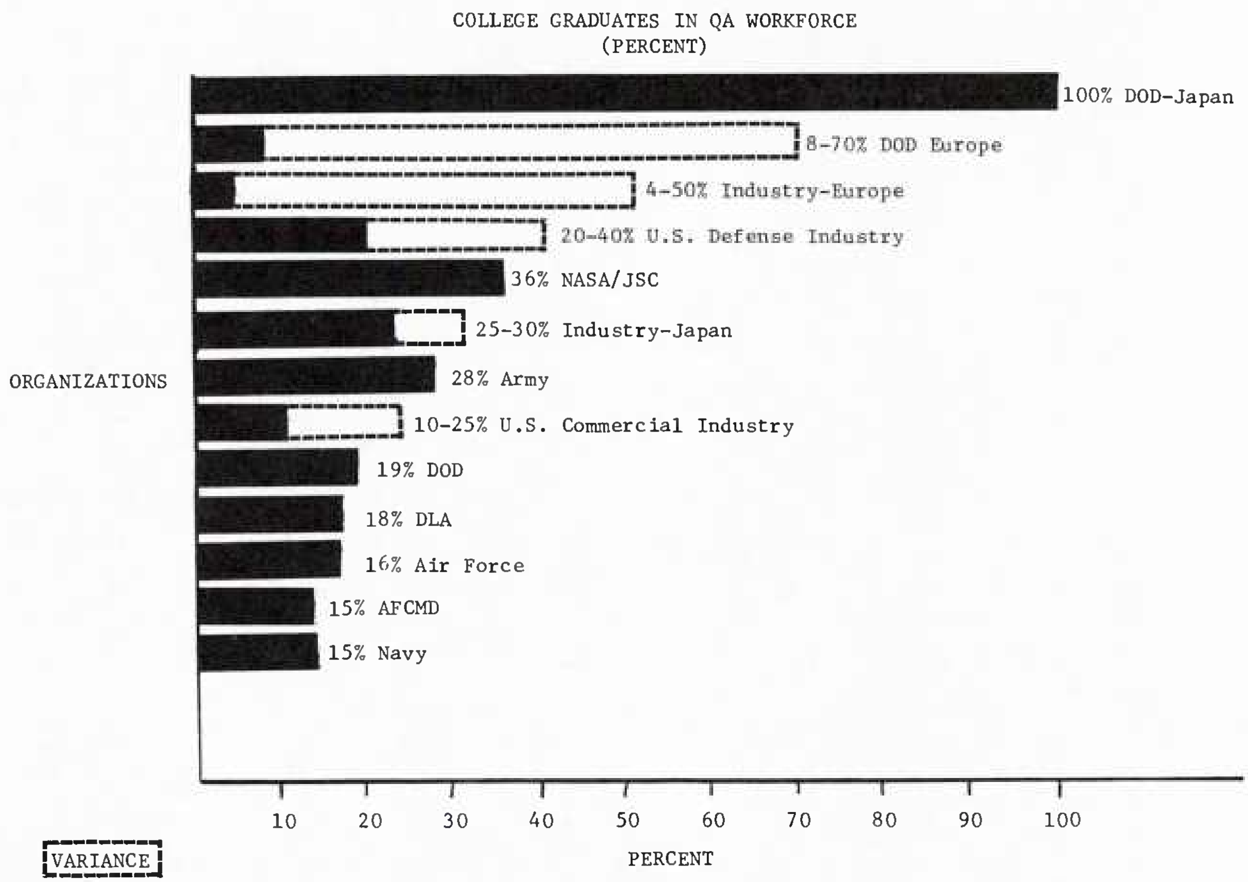

FIGURE 2

in the state-of-the-art only after they are proven; thus technical risk is generally low.

Competition is a strong driver when a vendor is to be chosen for a new program because vendors know that, for the most part, once they have the business, they will keep it. In almost all cases, commercial firms stay with a vendor once the vendor has produced a quality product. When a problem arises, the company and the vendor work together to try to resolve it. This is true throughout the United States and Europe, and is especially true in Japan. When large production quantities are involved, companies will dual or even triple source and maintain continuing competition that way. Even in those cases, vendors perceive the commercial business base as more stable than the Government's. One major consumer goods firm in the U.S. expressed extreme reluctance to change vendors. They stated that their success was first and foremost a result of long term relationships with their suppliers, and emphasized the difficulty and expense of introducing a new vendor to their requirements and business methods.

Specification control by the manufacturer is an important aspect of the commercial business environment. Performance specifications are called out, with the "how to" left to the vendor. The performance requirements are generally well defined and even if it is found that customer demands are different than expected, changes are controlled by the manufacturer. Firms will accept customer specified equipment, but may disclaim any responsibility for that equipment. In the case of consumer goods, customer satisfaction is more important than specification compliance. In other words, is the product suitable for its intended use? One company expressed it this way: DOD is devoted to specification requirements; commercial customers are devoted to results.

Customers have no unilateral right to direct changes in commercial contracts. This means that changes must be negotiated technically, and priced, before they are made. This allows the vendor more stability in his planning and manufacturing, and thus contributes to the ability of vendors to establish firm prices for work that the Government would buy using an incentive arrangement. One U.S. firm told the team they would accept more FFP Government contracts if the "Changes" article were omitted.

Commercial pricing is done more on the basis of market value and competition than cost plus profit. A vendor can include whatever contingencies he feels the traffic will bear, knowing that he can price himself out of the market if the competition provides an equal quality product at a lower price or a better quality product for the

same price. The low bidder is not always the winner in the commercial world. Almost all the firms interviewed were willing to pay a higher price to deal with a vendor they were confident would satisfy their requirements, provided they were not gouged. Customer demands for quality are increasing, and industry has perceived that customers will pay more for a quality product.

Past performance ranked high in their criteria for selection of a source. In fact, it is the dominant factor in many cases. A major aircraft manufacturer repeatedly told the team that the only way to achieve quality is to find a way to exclude the marginal performer from future business. Vendor rating systems are a vital part of the overall business strategy of the firms visited. The systems in use by the companies vary in sophistication with the complexity of equipment and amount of subcontracting involved, but they all serve to exclude the unacceptable vendor, and flag the questionable one so that suitable controls can be imposed. By regulation, the Government must buy from the low bidder unless he can be shown to be non-responsive or his technical approach does not fully satisfy the contractual requirement. The burden of proof, in a protest, is on the Government. Experience has shown that it is difficult to sustain a determination of non-responsibility or technical superiority. The low bidder rule is often cited as the reason the Government must stay fully engaged with its contractors. When cost analysis is used in commercial buying, the negotiators are often industrial engineers, or other technical experts knowledgeable about the product, rather than the accountants or financial experts the Government generally uses.

The general perception by a commercial firm is that the market is elastic to quality performance as well as price. They can make a determination of what the market will be and accomplish long range planning accordingly. They maintain they cannot make such determinations regarding the Government market. Government rules about competition and component breakout, along with the annual appropriations process, are cited as the primary reasons.

The teamwork aspect of the commercial company and its suppliers provides an interesting comparison with the relationship between the Government and its suppliers. Before award, the commercial firm is much tougher than the Government would be, using negotiation tools prohibited by our procedures, such as auction techniques. Once a vendor is selected, the relationship becomes a cooperative one, in pursuit of a common goal. The Government negotiating team, on the other hand, has generally cooperative arrangements before award, becoming adversarial after. In most cases, problems exasperate this adversary relationship, so that when the parties most need to be pulling together, they are likely to be engaged in a tug-of-war, where the solution to the problem takes a back seat to placement of the blame. Commercial firms tend to work a problem with industrial engineers and quality specialists, where the Government would use lawyers and accountants. Stable technology (commercial) vs advanced State-of-the-Art technology (Government) is a contributing factor to this situation.

Commercial warranties in the United States, Japan, and Europe tend to be relatively straight-forward and non-complex, applying to materials and workmanship only (not design or processes) for a specified period of operating time or calendar time. Warranty terms are usually established by competition, and firms try to get warranties from vendors consistent with the warranty they offer the consumer. In a number of cases, though, warranty costs are not charged back to the vendor unless they reach some previously established threshold of financial pain for the company. In several instances, this threshold was 3% of cost of sales. In some cases, the warranty is not even specified in the purchase order, but simply an understanding on the part of the vendor as to what level of quality is expected. Clearly in the commercial world both within and outside the United States, it is not the contract guarantee that drives quality; it is company policy and the promise of future business.

Firms that do a high volume of business in a product line generally have historical data to price warranties, but this becomes almost irrelevant at times, because the competition sets the terms of the guarantee. Often, firms decide to assume responsibility for correction of a defect on the basis of the cost of the correction and the predicted loss of customers if they do not make good, even though they have no legal obligation to do so.

The Quality Horizons team also observed a wide variety of contracting techniques, including warranty approaches, in the AFSC Product Divisions and the other Government agencies visited, both U.S. and foreign. All agencies used some firm fixed price and some form of cost reimbursement contracting. Cost-plus-a-percentage-of-cost (prohibited by law in U.S.) is still used to some extent in Germany, while Japan uses cost-reimbursement contracts with a ceiling arrangement which the supplier exceeds at his own risk. Fixed price was the preferred form in all locations. In Europe and Japan, one year warranties are used, covering materials and workmanship. In the U.S., DOD contracts range from CPFF to FFP, with a wide variety of incentive and warranty arrangements.

One incentive technique employed by DOD that is widely accepted as effective is Award Fee. This provision is generally used where there is inadequate information to prepare detailed specifications, where emphasis is subject to change during the life of a contract, or where an item of special importance to the Government is of only peripheral importance to the contractor. Award Fees are useful where warranties would not be, and they keep the communication channels open between the seller and the customer. At both

NASA, Houston, and a DOD contractor in California, an Award Fee allocation to Quality Assurance increased the stature of the QA organization by assuring visibility and emphasis by program and company management to the quality requirements. Thus, their participation was solicited commencing in the early design phase. Both Government and contractor program managers recognized a new emphasis on quality. The Quality Assurance manager of the California firm stated that with several hundred thousand dollars riding on quality he became an important part of the program management team.

The Navy's lease satellite program is the closest emulation of the commercial environment by a Government buying activity encountered. This satellite is to provide secure communications with ground stations for five years. All financing of this program is done by the contractor, with payments beginning when services begin, in orbit, in October 1981. A performance specification is used, and commercial time sharing is permitted. While the Navy will exercise close technical surveillance, design control remains with the contractor.

In all the AFSC Product Divisions, there is increasing emphasis on the use of warranty provisions; such as Reliability Improvement Warranties (RIW), Correction of Deficiencies (COD), and some limited use of standard commercial warranties. Unfortunately, use of a RIW or other guarantee has not generally resulted in reduced in-plant surveillance, or changes in contract quality management system requirements. Thus, the Government may be conducting needless contractor monitoring and paying additional costs. Whether the increasing use of these provisions has improved quality or whether they are cost effective is hard to judge at this point. It is generally agreed that RIW provisions are serving to improve the feedback of information to the manufacturer to assist in the correction process. Whether an effective warranty can be negotiated depends in large measure on the competitive nature of the purchase. The Government is generally able to include warranties in competitive contracts. In sole source situations, the contractor tries to establish a price that is prohibitive, or so emasculate the provision as to render it worthless.

There are more than enough tools available to the contract negotiator, but none of them are foolproof. There is no substitute for intelligent assessment of the government's objectives and selection of a business strategy consistent therewith. Ideally, the best contract would be referred to the least and the best warranty would never be referred to at all. Specific strategies for an acquisition should be tailored to the program and the contractor, keeping in mind that no form of assurance is free, and that the objective should be to get the most for the taxpayers' money.

STUDY SUMMARY

Many managers engaged in the military acquisition process on both the government and contractor sides give lip service to quality and the "ilities". Managers generally recognize the importance of these efforts and want front end attention to defect prevention, reliability and maintainability, but only to the extent that noncompeting funds are available to support their related costs. Detracting from the level of importance given to the "ilities" is a general lack of appreciation on management's part as to the trade-off analyses that are possible in these specialities. Thus, the manager often feels confronted with "all or nothing" choices as to "ility" requirements. Often neither of these choices would have resulted from a trade-off study which included the costs of product failures caused by the omission of these requirements. To establish tailored "ility" requirements that are consistent with cost, schedule and performance constraints requires sufficient manning and skill levels. Unfortunately, these levels are generally not available. Thus, the program manager may have inadequate information upon which to decide the apportionment of limited funds for competing requirements. Another factor contributing to the early de-emphasis of the "ilities" is that the pay-off from these programs is often not realized by the manager having this decision responsibility. The impacts of not performing these tasks are realized much later by the manager's successor or by the operational and support organizations.

In addition, many military and DOD contractor acquisition managers do not take the time and effort to fully understand the tools, techniques and benefits of the assurance engineering disciplines and some of the managers are also reluctant to properly man, fund or accept the recommendations of these specialists. Rational management decisions predicated on objective evidence of cost payoffs ie emphasized. However, it is often easier to measure the costs of failure, than to cost success in these disciplines. Managers must recognize that unless properly manned and funded, these functions cannot effectively or efficiently support the acquisition objectives nor can adequate information be provided so that well informed management decisions can be made.

STUDY RESULTS

Several recommendations of the study team were approved by General Slay on 15 January 1980. Major General Stansberry has been assigned the responsibility to assure that the recommendations are implemented. Below are some of the highlights of the approved recommendations.

A new organization is being established at the Headquarters, AFSC. It is called the Assistant for Product Assurance. The head of this office will be a Senior Executive Service level civilian who will report directly to General Slay. The office will also include three high level engineers specializing in the quality assurance, reliability and maintainability disciplines. Its

purpose will be to enhance the quality, reliability and maintainability of new weapon systems acquired by AFSC. General Slay has indicated that systems which perform consistently, even at reduced performance, are better than systems which meet stringent performance requirements but cannot be relied upon when needed.

Product assurance will receive much greater attention during the early acquisition phases of the weapon system life cycle. Regulations are under revision to assure that product assurance requirements are included in design, business strategy planning, program management planning, etc. Product assurance emphasis will be promoted through a series of briefings or video tape presentations to top management in AFSC. Manpower levels at the AFSC product divisions and AFCMD are being studied to see how product assurance manning can be increased in program offices. All of these efforts have the thrust of increasing management awareness and appreciation of product assurance and to increase product assurance involvement in program design and management decision making.

Several recommendations to enhance and upgrade the quality assurance workforce are in the process of implementation. Among them is a quality assurance intern program. This program will provide a continual source of highly qualified and motivated personnel to fill the vacancies created by retirements and other forms of attrition. The main theme of the program will be to develop individuals with the technical abilities necessary to perform effectively in journeymen level positions and who are also sensitized to program and business management. The training program will be three years in duration and will produce 25 graduates per year starting three years after the initiation of the program.

Also, a formalized training program for journeymen will be established. The program will assure that AFSC quality assurance personnel keep pace with industry and new technology in their areas of responsibility. Existing skill levels will be surveyed and skill needs determined. This program will satisfy the resultant gaps in the two. The program will be centrally managed by Headquarters AFSC.

To round out the overall training program, there will be a career development program. This program will contain a segment tailored for specific journeymen who have been identified as having the potential to fill our top quality assurance management positions in the future. Key AFSC quality assurance positions will be identified and individuals with the potential to fill these positions will be selected. The program will then provide the appropriate training and developmental assignments necessary to groom these individuals to attain these positions.

The curricula for those courses attended by future Air Force top managers will be reviewed. The intent is to determine whether there is sufficient coverage of the product assurance management function in acquisition and/or logistics courses and to revise those courses where coverage needs to be included or increased. This will contribute to the theory that all levels of management must have a strong appreciation for the benefits to be gained from a product assurance program and they must continuously support the program if the full value of the benefits is to be derived.

Several contracting approaches to enhance product quality have also been approved. The concept of accepting products after a period of use in the actual operating environment in lieu of acceptance at the contractors plant will be tested. It is anticipated that this procedure will motivate the contractor to build a better quality product environment. Similarly, the technique of leasing products instead of purchasing will be tried. Here too, more responsibility is shifted to the contractor. Another contracting approach is the use of progress payments as a tool to remedy quality problems. The Defense Acquisition Regulation authorizes the suspension or reduction of progress payments for failure to comply with material requirements of the contract. Contracting officers have been advised that this tool is available for their use when appropriate. AFSC is also exploring, with contractors, the expanded use of contractual warranties to improve quality. In addition, the use of award fee provisions will be expanded to include incentives for product assurance. This will provide the top management attention and motivation to product assurance that might otherwise be lacking.

All of the above actions will contribute to the objective of enhancing the quality of AFSC systems in the hands of the user. Most of these efforts will take time and continuous management attention to implement. It is only through the combined efforts of everyone in AFSC and its contractors that we can expect to see this objective come to fruition. This is only the beginning of a new era of product excellence in AFSC.

KC-10 WARRANTY AND SERVICE LIFE POLICY

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ABSTRACT

The basic philosophy of the KC-10 program has been to use commercial practices to the maximum extent possible. From the start, we have tried to insert ourselves into the commercial marketplace and act like any other aircraft customer. If the corporate entrepreneur can profit from this approach, why can't the Air Force? In the commercial marketplace, the competitors fight it out by offering their best overall "deal". While we recognized that we had to live within the framework of Government rules and regulations, we did attempt to obtain the optimal "deal" possible by permitting prospective contractors the opportunity to substitute commercial practice where possible and bid their "best business arrangement". The warranty and service life policy contained in the Douglas KC-10 contract today evolved from this "best business arrangement" approach.

I. BACKGROUND

Prior to releasing the solicitation, we obtained copies of the manufacturer's standard warranty provisions and compared them to the Correction of Deficiencies (COD) clause included in various major weapon systems contracts. Although it appeared that the standard commercial warranty was comparable to the COD, we felt more comfortable with the COD. We decided, however, that the best approach was to allow the contractors to propose their "best deal". This decision was based on:

a. The COD provision is typically very expensive to obtain.

b. The standard warranty provision is part of the commercial price and its deletion would have a negligible price impact.

c. It is used by the airlines. Why can't it work for us?

d. With contractor logistics support being competitively procured simultaneously with the aircraft acquisition, we could "flow thru" the responsibility for warranty administration to the logistics support contractor.

As a result of this approach, each aircraft manufacturer proposed his commercial warranty as part of his "best business arrangement". This included not only the basic warranty feature, but also a service life policy for extended coverage of selected structural components. During negotiation sessions with the Douglas Company, the eventual winner of the contract, the possibility of deleting the provisions was discussed. They advised against its deletion based on the following:

a. The provision, over a long period of time, has been successfully applied in the commercial marketplace. Both buyers and the seller are accustomed to its use and the "bugs" have been worked out.

b. Warranty costs are amortized over all aircraft and are not identifiable to one particular customer or one particular aircraft.

c. Because no cost history is available, there would be no price reduction should the clause be deleted from our contract.

d. If we don't want the warranty, we don't have to use it.

The end result was that Douglas' commercial "Warranty and Service Life Policy" provision was included in our contract, with minor modifications to accommodate the KC-10 program and its proposed utilization rate. The following paragraphs discuss these provisions in more detail.

II. WARRANTY PROVISIONS

The commercial provision is a lengthy and complicated provision that sets forth what the manufacturer will warrant and what the customer must do to maintain the effectivity of the warranty.

What does the warranty cover? The aircraft structure, systems, accessories, equipment and all parts of the aircraft are covered under the warranty provision. This sounds as if the whole aircraft is adequately covered. However, one must look at the fine print to find the qualifiers. These items are covered if they are:

a. Manufactured by the contractor, or

b. Manufactured by others if made to the de-

tailed design and detailed specifications originated by the contractor.

Those structures, systems, accessories, equipment and parts that are not manufactured in accordance with the above constraints fall into the area of vendor warranty coverage, which will be discussed later.

We were able to obtain coverage over and above that generally offered to the commercial customer in the following areas:

a. The aircraft which the contractor has warranted is the KC-10 aircraft which means that the KC-10 peculiar additions to the DC-10 model are also covered as a part of this warranty. Additionally, in most critical KC-10 peculiar areas, Douglas has or will develop the design and the specifications for the changes.

b. The contractor has included spare or replacement parts as part of the warranty.

What defects are covered? The contractor warrants that the aircraft structure, systems, accessories, equipment and parts will be free from the following defects at the time of delivery:

a. Defects in material and workmanship.

b. Defects caused by installation by the contractor of any article not manufactured by the contractor in a manner which is not in accordance with the reasonable instructions of the manufacturer.

c. Defects arising from failure to conform to the Detail Specification in effect at the time of delivery.

These defects must become apparent to the customer within sixty (60) months or five thousand (5000) flying hours, whichever first expires after aircraft delivery. Because of the low utilization rate anticipated for the KC-10, the normal commercial warranty time period of two (2) years was raised to five (5) years; however, the flying hours remained the same.

In addition to the defects indicated above, defects in design including defects arising from selection by the contractor of materials or process of manufacture are also warranted. These defects must become apparent to the customer within twenty-four (24) months after aircraft delivery. The normal commercial warranty time period is eighteen (18) months. No flying hour rate is tied to this warranted defect.

What about billback provisions? Several GAO reports dealing with commercial vehicle warranties were concerned that standard billback agreements were not included as part of the warranty package. Billback agreements deal with the ability of the customer to make warranted repairs and obtain reimbursement from the manufacturer because it is impractical to return vehicles to an authorized dealer. A similar question could be raised concerning our warranty. The KC-10 warranty does have a billback agreement which allows either the Government or the logistics support contractor to perform repairs and bill the manufacturer. Reimbursement procedures are set forth in the clause along with the method of calculating labor hours and burden.

What conditions must the customer comply with? The clause stipulates the conditions which, if violated by the customer, will void the warranty. The contractor shall be relieved of all liability if:

a. The aircraft is operated with any accessory, equipment or part not specifically approved by the contractor.

b. The aircraft is not operated or maintained in accordance with the contractor's operating and maintaining instructions.

c. The aircraft is not operated under normal KC-10 mission use.

d. The aircraft is repaired, altered or modified without the contractor's approval.

e. The aircraft is operated after involvement in an accident.

These conditions are all qualified in the clause to the extent that, if the customer can provide reasonable evidence that the particular condition was not the cause of the defect, the warranty will remain effective.

There are also administrative conditions that affect the customer's rights under the warranty provision. The contractor shall be relieved of his obligations under the clause if:

a. The customer does not report the defect in writing to the Contractor's Warranty Administrator within sixty (60) days after the defect becomes apparent to the customer.

b. The customer fails to return the defective or faulty aircraft, accessory, equipment or part to the contractor within sixty (60) days after the defect becomes apparent.

c. The customer does not submit reasonable proof to the contractor within sixty (60) days that the defect is due to a matter embraced by the warranty.

The particulars and the time periods for these administrative conditions may be waived as long as the contractor is notified and approves of the circumstances.

Is there a "re-warranty" feature? The standard commercial warranty does not contain a

"re-warranty" provision which would "start the clock" again on those accessories, equipment, or parts which become defective under the clause and are replaced with new items. Our research showed that such a "re-warranty" feature was offered to some favored customers as part of side agreements and it was added to our warranty protection.

What else is covered under the warranty besides the aircraft? We were able to obtain expanded coverage over and above that generally offered to the commercial customer. Warranty coverage has been extended to support equipment, configuration alternate kits and spare or replacement parts. In addition, since the intent was to expand the warranty to cover all deliverable items, any items added to the contract in the future should also be extended the same coverage.

III. VENDOR WARRANTIES

Our contract calls for the flow-thru of all vendor warranties to either the Air Force or the Logistics Support Contractor. In addition, the contractor will make reasonable efforts to obtain vendor warranties on all items not covered by the contractor's basic warranty. Through his purchasing activity, the contractor is also attempting to secure the same extended coverage as stated in his basic warranty even on those items where vendor warranty coverage already exists. Even though our aircraft buy is small and unstable, vendors are willing to "play ball" because of the leverage being applied by Douglas in conjunction with commercial developmental programs such as the Super 80, etc.

What happens if a vendor breaches his warranty? The contractor has agreed to assist in obtaining resolution of any warranty problems with his vendors. If there is an ultimate breach of warranty by his vendor, Douglas has agreed to apply his warranty in the same manner as though they had originally manufactured the item. This is true of all accessories, equipments or parts with the exception of engines.

What is the coverage for engines? There is a specific engine warranty which is detailed enough to be the subject of a separate analysis. For our purposes here, the following summarizes the coverage provided by the engine manufacturer as part of his warranty and service life policy:

a. New engine/module/reverser
   0-2000 hours - 100% coverage
   2000-2500 hours - pro rata basis

b. New parts
   0-1000 hours - 100% coverage
   1000 hours - pro rata depending on part, e.g.:

   1st stage disk - 12,000 hours
   1st stage blade - 3,000 hours

c. Ultimate Life Warranty
   Pro rata up to 25,000 hours/15,000 cycles

The engine warranty is a vendor warranty and is separate from the aircraft coverage. Additionally, the aircraft manufacturer will not stand behind the engine warranty as he will other vendor warranties.

IV. SERVICE LIFE POLICY

In addition to the basic warranty, the contractor also provides additional coverage of selected components through his service life policy. This policy covers primary structural elements of the following:

a. Airframe Components
   Pylons - Wing and center engine
   Wings
   Fuselage
   Empennage

b. Landing Gear Components
   Main Gear and Center Line Gear
   Nose Gear

The period of effectivity for these components is as follows:

a. Airframe components - 30,000 flying hours or ten (10) years after aircraft delivery, whichever expires first.

b. Landing Gear Components - 20,000 landings or 30,000 flying hours or within ten (10) years after aircraft delivery, whichever expires first.

If a covered component requires replacing, the customer's price for replacement will be determined in accordance with formula stated in the contract. The actual number of flying hours, landings or years after delivery will be compared to the period effectivity numbers stated above in order to derive each party's pro rata share in the price.

Similar conditions on the customer to those of the warranty provision are also applicable to the service life policy.

V. CURRENT EMPHASIS ON WARRANTIES BY GAO

During recent years, there has been increased emphasis in commercial warranties. In particular, the recent GAO report on manufacturer's warranties (79-051 dtd 16 Feb 79) pointed out deficiencies in the Government's use of these warranties. We measure up to these deficient areas as follows:

a. Price of Warranty Coverage - The warranty and service life policy in the KC-10 contract was included as part of the commercial price of the aircraft. During source selection, the contractor validated his price by use of a DD Form 633-7. This commercial price was then audited and compared to the prices for similar type aircraft offered in the commercial marketplace. As further protection, the contractor signed up to a most favored customer warranty

which certifies that the Air Force will pay the same or lower price for aircraft as the contractor's best customer - throughout the life of our contract. Although the exact price paid for the warranty coverage is unknown, the price protections described above and the added areas of coverage as described below more than adequately justify the reasonableness of the warranty coverage in the KC-10 contract:

(1) DC-10 coverage extended to KC-10 peculiar additions.

(2) Warranty coverage extended to support equipment, kits and spare or replacement parts.

(3) Period of coverage extended.

(4) Re-warranty feature added.

b. Passthrough of Subcontract Warranties - The KC-10 warranty coverage calls for the vendor flow-thru of warranties. In addition, the contractor has agreed to stand behind the vendor warranties in case of vendor breach.

c. Warranties not Emphasized for Correction of Defects - The KC-10 program is unique from the standpoint that the aircraft will have contractor logistics support. And the logistics support contractor and the aircraft manufacturer are one and the same. We have structured our warranty provisions to permit the same rights afforded the Government under such provisions to be passed through to the logistics support contractor. From the outset of the KC-10 program, all bidders were told that the eventual logistics support contractor must have rights to the warranties and would administer all warranties, including vendor warranties. Each logistics support bidder was encouraged to take into account the use of these warranties in developing their investment material ceiling price and their flying hour rate.

Douglas, as the aircraft manufacturer with a separate corporate pool of money for warranty claims and as the logistics support contractor with their contract funding, must make some interesting trade-offs in the warranty area during the course of these contracts. They are required to maintain the effectivity of all warranties so that any active warranties can be passed to the Air Force upon expiration of the contract period. Assuming that Douglas corporate strategy is to make the KC-10 a separate profit center, it would behoove the logistics support contractor to use the cost benefits that the warranties offer to minimize actual expenditures against the contract. This will make their report card look good from a corporate viewpoint and, also, fulfill the contract requirements to keep the warranties active.

The Air Force plans to enforce the manufacturer's warranty on design deficiencies. AF personnel will be instructed regarding procedures to be taken should a deficiency become apparent. Although the logistics support contractor is the logical intermediary for deficiency corrections, an Air Force claim to the manufacturer would be a viable alternative should complete satisfaction not be attained.

VI. CONCLUSION

In spite of the logistics support contractor's responsibilities in the warranty area, we must make sure that the Air Force does not accidently contribute to voiding any warranty and, thus, cause an impact to the KC-10 logistics support contract. This is particularly true of our "remove and replace" operation on the flight line.

We will continue to learn as much about aircraft warranties as we can and pass on our findings to anyone who will listen. However, the real learning experiences will come in late 1980 - early 1981 when the first KC-10's are delivered to the Air Force.

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BAKKE, WEBER AND AFFIRMATIVE ACTION IN THE 1980'S

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ABSTRACT

The landmark Supreme Court decisions, Bakke and Weber, are perhaps the most celebrated and controversial civil rights cases in the past 25 years. This research will assess their impact on the present status of affirmative action and the implications they present for the 1980's. Fundamental to this analysis will be a consideration of the Executive Order 11246 and 11478 and their interrelation with Title VII of the Civil Rights Act of 1964 and the Equal Protection Clause of the Constitution. Key questions will be the viability of voluntary affirmative action plans, the roles of EEOC and OFCCP in this process, and the likelihood of extension of these concepts to other minority groups. Implicit in the discussion will be a treatment of the emotionally charged issues of "reverse discrimination" and "preferential treatment." The impact and directions indicated by these decisions must be clearly understood by Federal, private, and public sector employers in order to prevent delays, pre-award complications, avoidable litigation, misunderstandings, and resentment which will clearly affect their ability to provide the goods and services contracted.

BAKKE AND ITS IMPLICATIONS

Regents of the University of California v. Bakke, (1) which has received unparalleled publicity perhaps, in part, due to its potentiality to hault and reverse the cause of minorities obtaining equal access and opportunity in a wide spectrum of activities, has been heralded as the most important civil rights case before the Supreme Court since Brown v. Board of Education in 1954.

In his case, Bakke charged that the University of California at Davis Medical School special admissions program, which reserved 16 of the 100 first year class places for certain racial minority students, violated the Equal Protection Clause of the 14th Amendment and Title VI of the Civil Rights Act of 1964. The decision affirmed the lower court order admitting Allan Bakke to the medical school and declared the special admissions program of the school unlawful, but that portion of the order prohibiting the school from considering race in future admissions decisions was reversed. Nevertheless, the unusual 4-1-4 split among the justices indicates the differing reasoning and conclusions which revolve around nearly every issue of the case and may be, in fact, indicative of the pervasive confusion throughout the country on this emotion-charged issue.

In essence, four justices would prohibit all racial preferences of any kind under Title VI and its legislative history, while four would permit any racial preference, including numerically fixed quotas reasonably designed to remedy racial discrimination. The deciding, though not majority, opinion by Justice Powell should be viewed carefully in the narrowest terms for what it says and the broadest terms for what it omits.

Powell reasoned that although the special admissions program as presented violated the 14th Amendment and Title VI since it failed to evaluate special admission minority applicants, benign racial factors could be considered after strict judicial review. This review must consider whether anyone's rights had been abridged, exclusion from meaningful participation, or a prior judicial, legislative, or administrative findings of past racial discrimination. Failing these criteria, the racial classification must serve some compelling state interest. Of the compelling state interests presented by Davis, Powell only accorded some acceptance to the attainment of a diverse student body as being sufficiently compelling to justify this action (2).

The results of the complicated and carefully worded opinions is that from a legal perspective, Bakke has changed little at all. While permitting the diverse student body interest, Powell does not say this is the only justifiable compelling state interest. Bakke demonstrates no effect whatsoever on involuntary affirmative action admissions programs which have been instituted pursuant to a competent finding of past discrimination.

There was wide speculation that the affirmative action basis laid in Bakke should apply to sex as well as race, and to employment as well as university admissions policies, although the case did not directly relate to either.

There was encouragement that although the Davis numerical goals were rejected there was no across the board ban against the use of such measures to redress discrimination. In a case dealing specifically with sex discrimination, the Supreme Court, in a decision a week after the Bakke decision, let stand a major affirmative action program adopted in 1973 by American Telephone and Telegraph by declining to review Communication Workers of America et al v. EEOC. (3)

While this step gave feminists some encouragement, there is disappointment in Bakke on this point in that Justice Powell issued dicta which said that equal protection guarantees of the 5th and 14th Amendments will not be extended fully to women because the gender-based classifications have never, in his view, reached the level to be as inherently suspect as racial or ethnic classifications.

There is also reason for concern in that Bakke raised and left unresolved the question of whether private parties have a right to go to court and seek enforcement of civil rights statutes. Some doubt in this area was removed by Cannon v. University of Chicago (4) which maintained plaintiff's right to sue under Title IX despite a lack of express authorization.

Although often discussed, it is clear that Bakke cannot specifically speak to the employment issue since it dealt with education and Title VI only. After Bakke, it seems nevertheless, that a court is most likely to uphold the validity of an affirmative action plan if there is a showing that it has been designed in response to a definite need for affirmative action, a remedy for past discrimination by the employer, and when the remedial action taken is consistent with that which has been awarded in similar circumstances. This is strongest when there has been a determination of past discriminatory practice or effect by EEOC, as in EEOC v. Contour Lounge Chair Co. Inc. (5) EEOC is also prepared to offer a letter to contractors who develop affirmative action plans (AAP) according to its guidelines which the company can use in court as a defense should a reverse discrimination challenge be raised.

Courts are particularly likely to find an AAP unlawful if there was no prior discrimination by the employer or if the AAP went far beyond the proper judicial remedy for past discrimination. In this connection, basing its decision on Bakke, the California Supreme Court found in Hull v. Cason (6) that the quota provisions of a court order which required the Oakland Fire Dept. to overcome the effects of past racial bias by hiring and promoting specific percentages of minority group members violated the 14th Amendment and Title VII. Noting that the city had attempted to achieve a racially balanced department for many years, it upheld lower court findings that such affirmative relief should not be permitted against a public employer that had neither the intent nor purpose to discriminate.

It averred "clear authority that a minority person quota provision having the effect of discriminating against faultless Caucasions on the basis of race alone is unlawful." (6)

However, a city's AAP calling for a good faith effort to achieve 15% minority employment on city construction projects is proper. Citing Bakke, a Federal District Court ruled in IBEW Local Union No. 35 v. City of Hartford (7) that the city council's legislative findings of past discrimination in the area of construction trades justified enactment of the plan without proof of discrimination by any specific contractor. The court found that the AAP did not impact in an unduly burdensome manner because nonminority worker opportunities were only delayed and not totally foreclosed.

These cases are further supported by an EEOC internal memo which conceded that, in light of the Court's concern for "innocent whites," an employer procedes at risk if, without specific government approval, he extends a preference to minorities or women that deprives white males of "hard expectations," such as promotion and/or seniority rights. (8)

In analysing the potentiality of reverse discrimination, the following should be considered:

- Does the AAP have an adverse impact on males and nonminorities?
- If so, is it dispersed among victims not identifiable?
- Was the AAP adopted voluntarily or in order to satisfy federal civil rights laws?
- Has the employer acted in good faith in establishing the AAP and does that matter?
- Does the AAP attempt to remedy past discrimination or to attain racial or sexual balance?
- Is a bonafide seniority system involved? (9)

In an attempt to clarify the situation and to help protect employers from conflicting suits by women and minorities on one side and white males on the other, the EEOC has issued some proposed guidelines on affirmative action which are designed to mitigate the confusion and doubt. However, a former EEOC attorney now in private practice, claims that the final version must be substantially revised if they are to be effective. David A. Copus maintains the Commission must confine its use of voluntary quotas to the most narrow circumstances to avoid constitutional challenges. The draft guidelines evidence some serious problems in that they explicitly state that the government need not have evidence sufficient to prove that the employer has violated Title VII in order to require the firm to undertake affirmative action. (10)

While only one justice found the Davis affirmative action provisions violative of the 14th Amendment, four others avoided a finding on that issue basing their determinations on Title VI only. This raises the question of whether affirmative action would stop if it were found that, under the 14th Amendment, the states may not

engage in affirmative action programs. In short, is it within the province of the Congress to do what the states may be precluded from doing in this matter.

Generally, congressional authority to order employers to implement affirmative action efforts may be derived from three sources: The 14th Amendment, the Commerce Cluase, and the Necessary and Proper Clause of the Constitution.

The Necessary and Proper Clause is the source of congressional power over federal workers. In situations involving the hiring and promotion of federal employees, the Supreme Court has reaffirmed congressional authority in the affirmative action area. The seminal case in this area is Morton v. Mancari (11), where the federal government was permitted to accord preferential promotions to Indians employed in the Bureau of Indian Affairs by means of a "criterion reasonably designed to further the cause of Indian self-government and to make BIA more responsive to the needs of its constituent groups."

With respect to non-federal employees, authority of Congress to institute affirmative action may be derived from Commerce Clause or 14th Amendment. Although the 14th Amendment has not been precluded as a basis for affirmative action, and Bakke does not further that effort, there is reason to believe that this will be an area of continued attack in that equal protection has traditionally been interpreted to mean a bar to discriminatory treatment on account of race. While some would interpret the 14th Amendment Equal Protection provisions as meaning economic as well as political equality, most rely on the McDonald v. Santa Fe Trail Transportation Co. (12) interpretation which found a congressional intent to deal equally with members of both races without according advantage to a member of any particular race.

It has been suggested that the Commerce Clause may provide a sounder basis for future affirmative action efforts. (13) The Commerce Clause allows Congress to subject almost any business to federal regulation. This has been found to include any business that merely affects interstate or international trade. Title VII has already been affirmed under the commerce power by cases such as EEOC v. Rinella & Rinella, (14) where a local law firm, sued for Title VII discrimination, was subject to federal scrutiny in that such law firms do affect interstate commerce.

WEBER AND ITS IMPLICATIONS

In June, 1979, after much controversy and speculation, the Supreme Court issued Phase II in its review and interpretation of Civil Rights Law. While many looked for far-reaching implications on the employment scene since the case was brought primarily under Title VII, the narrowness and limitations of the opinion have almost raised more questions than were answered.

At issue in United Steel Workers of America v. Weber (15) is a provision under the collective bargaining agreement which would establish an on-the-job training program to teach unskilled production workers the requisite skills for them to become craft workers, where there was a severe underrepresentation of minority workers. Although technically speaking, the plan was "voluntary", it was only adopted after the company, Kaiser Aluminum and Chemical Corp., had received unfavorable reviews from the Office of Federal Contract Compliance (OFCCP), who are charged with the review of federal contractors for affirmative action compliance. Modeled after a nation-wide consent decree throughout the steel industry, the plan called for a 50% set aside for blacks, with seniority the basis of selection, until the plant was in parity with the Standard Metropolitan Statistical Area (SMSA) of Gramercy, Louisiana, the plant site (39%). Prior to the plan, only 1.83% of the craft workers and 15% of the plant overall were minority. In the first trainee class, 7 of the 13 trainees were black. The most junior black selected for the program had less seniority than a number of white applicants, including Brian Weber. He brought a class action on behalf of others similarly situated claiming that the selection procedure denied access to on-the-job training programs on the basis of race and, thus, was violative of §703(a) and (d) of Title VII.

The majority opinion concluded that Title VII must be read against the background of its legislative history and purpose. Analysis of that history convinced the majority that Congress' goal was to open employment opportunities for minorities, especially blacks, by passage of that legislation. Thus, it would be inconsistent with the legislative purpose to interpret Title VII to prohibit private affirmative action programs designed to further that goal.

The obvious stumbling block was the language of Title VII, which makes it unlawful to "discriminate because of race" in hiring and in the selection of workers for training programs in §703(a) and (d). (16) To avoid these problems, the court looked to Section 703(j) which says that "nothing in Title VII shall be interpreted to require any employer to grant preferential treatment... to any group because of...race." The use of the word "require" rather than "permit" creates the inference that Congress chose not to forbid all voluntary race-conscious affirmative action.

The Court placed great emphasis on the fact that the craft positions had been traditionally race segregated in our society and the fact that Kaiser had such a small number of minorities in those positions. There was no admission of past discrimination, nor even "arguable" past discrimination. Neither was there an endorsement of any actions taken pursuant to an AAP. The Court noted that the Kaiser-USW plan was a temporary plan designed to eliminate a manifest racial imbalance rather than to maintain a racial balance. Also, the plan did not "unnecessarily trammel" the interests of white workers by requiring their discharge or erecting an absolute bar to their advancement.

In spite of its questionable projected impact, EEO officials were quick to herald the decision as an immediate boost to EEO efforts. According to Eleanor Holmes Norton, Chair of EEOC, "Weber means that employers and unions need no longer fear their affirmative action programs will be open to legal challenge. It is safer (for employers) to adopt a program than wait to be sued... the court appears to have done away with the reverse discrimination issue in employment disscrimination." (17) Also, Michael R. Frontham, the New Orleans lawyer who represented Weber, conceded that "it's a green light for Federal agencies doing affirmative action."

It appears, however, that the decision in many important aspects is basically inconsistent with the result reached one year earlier. The Weber case is expressly narrow, dealing only with prohibitions on voluntary conduct of private employers as written in Title VII. It makes no pretext to speak for constitutional issues such as the extent to which government can mandate or participate in similar affirmative action programs. In all probability, it is the narrow scope of the decision which enabled the Court to reach a 5-justice majority.

In spite of the similar language in Title VI and Title VII as parts of the same statute, passed at the same time, the basic difference between their application which resulted in the differing outcomes may lie in the fact that Title VI involved Congressional power over the use of federal funds while Title VII had a different constitutional basis in Commerce.

One author explained the differing outcomes by concluding that the Supreme Court was aware of "our society's history of employment discrimination and was convinced that numerically-based AAPs were essential in an employment context to achieve the goals sought by Congress in Title VII" (18) For these reasons, the Court felt it should read Title VII in a broader and perhaps more results oriented context than Title VI.

While voluntary race-conscious and affirmative employment decisions may be more firmly rooted in legal precedent in some very specific circumstances, there are many open questions concerning the limits of permissible affirmative action and who may be included in its findings. On the one hand, the Court's decision defines for employers the permissible range within which they may establish programs to reduce imbalances in their work forces. However, at the same time, some employers who had hoped that the Court would look permissibly on quotas only for identifiable victims of past discrimination were flatly disappointed by the court's ingenious reading.

It has been said that courts will look more favorably on employers and unions that take voluntary action to end discrimination than those who do not. Similarly, the emphasis on underrepresentation in craft jobs will probably be extended to other types of positions. Sales, engineering, and middle management are likely targets since a conspicuous imbalance has traditionally existed in these areas. (19)

It has been stated that affirmative action efforts will be permissible under Title VII to "remedy manifest racial imbalance, and to remove old patterns of racial segregation and hierarchy." While it is also clear that the type of statistical imbalance demonstrated in the Kaiser plants was sufficient evidence of traditional racial segregation to warrant action, there are no clear guidelines on how an employer should know if its work force is in need of this type of action. Implicit is the understanding that affirmative action might be less justifiable where there exist less dramatic numerical differentials between white and black employees. Since the court has shown disfavor toward plans instituted solely for the purpose of maintaining a racial balance, it would seem that employers must consider a careful self-analysis prior to the initiation of an affirmative action program voluntarily. An employer will be on safest grounds when acting in response to extreme statistical variations--whether the result of societal patterns or traditional segregation. Race conscious decisions based on less clear statistical variations may still prove problematic.

Another important factor in the Weber plan which led to its acceptance by the Court was that it did not "unnecessarily trammel the interests of white employees." A plan which had a more dramatic effect on the plight of innocent caucasians might have met with a different fate. While a 50% quota for blacks is permissible, it is questionable whether an exclusionary 100% quota would be acceptable unless it were sharply defined and limited to minimize its impact on innocent whites. The training context of Weber was relatively easy for the Court; it noted that Brian Weber was not discharged, nor was he forever barred from entry into other training programs.

Although not specifically referenced, it seems that the role of the USW in the design of the AAP may have been a key factor in its acceptance by the Court and its evaluation of the plan's impact on white workers. It is fundamental that a union be brought into any discussions on an AAP where that union is the exclusive bargaining agent for incumbent employees. While a union may at times raise obstacles or objections to an employer's proposed affirmative action plan, the union does represent important employee interests and may share in any Title VII liability arising out of collectively bargained employment practices.

Another key element and possibly indispensable to the success of any plan is its temporary nature. As with the Kaiser-USW AAP, the permissible AAP should be addressed to eliminate the effects of past societal discrimination and should cease when that result is achieved.

There remains some confusion in OFCCP procedures on how this will affect its goal setting devices. Until recently, a compliance officer, in determining an area of underutilization, would guide the

company on the establishment of a series of short-term, ultimate, and contingency goals. The ultimate goal would reflect the ideal parity with short-term goals measuring progress toward that goal over a period of years. A contingency goal is routinely also suggested whereby the company would agree that, once the ultimate goal is attained, a specific percentage of hires, promotions, etc., would be targeted for the purpose of maintaining that goal, in order to avoid situations where a company would achieve parity and by neglect to the program possibly return to a pre-OFCCP review status. It appears that such maintenance measures are unacceptable after Weber.

Recent guidelines of OFCCP have stressed the use of a statistical device called the Adverse Impact Ratio Analysis, which replaces the contingency goal analysis with annual numerical goals and ultimate percentage goals. In theory, this will lessen the impact of static goals in developing companies since the actual numbers required to fulfill the percentage goal will increase as the company grows and the company will be committed to the numerical annual goals previously outlined. While in some instances, this may result in the extension of the plan for a few additional years, the indefinite character of the contingency goals will be averted.

In avoiding claims of reverse discrimination, the following guidelines should be considered:

- If passing scores on qualifying tests are lowered, in order to permit more minority group persons to pass, they should be lowered for all applicants.
- Unilateral action by an employer that affects jobs under a collective bargaining agreement is hazardous.
- It is also hazardous for a union to take unilateral action against an employer that has a good civil rights record.
- A quota involving more than a 50% set-aside for women and minorities might be struck down. If a 50% standard won't achieve a balanced work force, the time frame should be extended. (Although the Weber program would take 30 years to accomplish, it was still characterized as temporary). (20)

There has also been some concern voiced by other minorities on the applicability of Weber to those situations. Most feel that women and other minorities are intended to be included by applying similar rationales for discriminatory impact in situations dealing with reasons other than race. Hispanics, women, and other disadvantaged ethnic groups have been quick to view Weber as a tool to expand their positions and gains. While other minorities and women are not mentioned, most legal experts feel that other racial minorities such as Hispanics will surely benefit.

While the case of AAPs for women has always been less sure than that of racial minorities, a recent decision, Edmundson v. U. S. Steel Corp. (21) involving apprenticeship program preference for women was clearly permissible under the Weber standards. Since gains by women in this area have generally been harder won, there is even more reason to assume Weber expansion to other minority groups.

While EEOC Chair Norton was convinced the Weber ruling applied to public employers as well as private ones, many other legal experts were less sure in view of the avowed strict limitations placed on Weber. Much of this controversy rests on whether affirmative action may be based on the 14th Amendment Equal Protection Clause or the Commerce Clause. By the EEO Act of 1972 and Public Law 92-261, Congress expanded Title VII affirmative action coverage to include state employees.

In Fitzpatrick v. Blitzer, (22) the Court determined that congressional Title VII power over public sector workers emanated from the 14th Amendment are constitutionally questionable in view of Bakke and McDonald. This implies that the 14th Amendment may forbid states from sanctioning unequal treatment based on race and also that the 1972 amendments may be unconstitutional since they order states to engage in affirmative action.

Since Fitzpatrick seemed to hold that congressional power over persons who worked for the state as a sovereign emanated from the 14th Amendment, it became essential to distinguish between persons who worked for the state as a state or the state as a proprietor (in which case the employees would be governed by the Commerce Clause). The distinction was based on effect on interstate commerce and profit margins. Ultimately, it seemed that if a state made a profit and was involved in interstate commerce, affirmative action would be governed under Commerce Clause. But if the state services had begun prior to the extension of Title VII to the States, the state would be treated as a sovereign and thereby governed by the 14th Amendment.

Since 1972, there have been several attempts to clarify the obligations of the state as a public employer to affirmative action mandates. The courts have held that the legislative history of the 1972 amendments demonstrated the intent of Congress to include states within Title VII's coverage and any existing immunity of states from liability for discriminatory practices has been abrogated. Other cases have upheld the rights of a city to implement a voluntary affirmative action plan which aids "a class of persons identified as likely victims of discrimination." (23) Extending the Weber analysis, public employer plans which do not hamper unnecessarily the interests of white employees will meet with approval.

The Courts have been reluctant to strike down plans which rely on seminal cases (Furnco and Teamsters), (24) which say that Title VII does not require hiring practices that maximize the hiring of minorities or require that the work force reflect the racial makeup of the population. Most courts have not read those cases as a limit to voluntary remedial efforts permitted by Title VII.

In a further clarification to public employers, the Detroit Police Association v. Young (25) rejected the reverse discrimination claims of white officers that the AAP adopted by the City of Detroit, which was designed to produce a 50% minority composition in the police department in response to the 46% Detroit labor market, operated in a discriminatory fashion. In determining guidance in suits of this magnitude, reasonableness of the plan, the role of past discrimination in present underrepresentation situations, and the degree of stigmatization have become guideposts. In treating the likely victims of discrimination the court said,

> "Local government's voluntary affirmative action plan that is adopted to correct substantial and chronic minority group underrepresentation, that reasonably utilizes race without stigmatizing any group or individual, and that is the sole means of achieving plan's goals does not violate 14th Amendment's Equal Protection Clause." (25)

Application of Weber and Bakke beyond the scope of private employment is tenuous at best. Government is the largest single employer in the United States and at federal, state, and local levels must be considered a major element in the national work force. Nevertheless, government employment decisions at all levels are subject to the constitutional requirements of due process and equal protection that do not apply specifically to private employers. It is, therefore, problematic that the constitutional issues surrounding what government can require of private employers, also are integral to the question of what government itself can do in its own employment decisions. While the trend is for uniform application of law in all sectors, there can be no blanket approval of AAPs and extensive recruitment programs will be required by EEOC who now monitors Federal internal EEO efforts.

EXECUTIVE ORDER 11246 AND ITS IMPLICATIONS

Over half of the nation's industries are covered under the auspices of Executive Order 11246, including some 175,000 companies and 41 million employees. Therefore, a large segment of the affirmative action picture must center around Federal government and its enforcement of the guidelines presented by these regulations.

The executive order program, authority from the President to regulate the goods and services procured by the Federal government, was not a product of the 1960's. In fact, every President since Franklin D. Roosevelt in 1941 has issued an executive order forbidding discrimination in government contracts. The most recent major change was made in 1965, when President Johnson promulgated Executive Order 11246. In essence, this Order retained the same nondiscrimination and affirmative action obligations imposed by prior orders and extended their application further to include more contractor activities. Additionally, pursuant to the general provisions of the Order, specific rules and regulations have been issued for implementation of the Order.

The rules and regulations require that every contractor and subcontractor having 50 or more employees and a contract or subcontract of $50,000 or more must annually file an EEO-1 report and file such report within 30 days after the award of a government contract. Further, within 120 days of the commencement of the contract, the contractor must develop a written AAP which must contain a detailed analysis on the utilization of minority employees, and where deficiencies in such utilization exist, establish specific goals and realistic timetables for the prompt achievement of full and equal employment opportunity. In the case of contracts of $1,000,000 or more, the contract may not be awarded until there has been an OFCCP compliance review. OFCCP of the Dept. of Labor is charged with the responsibility of monitoring the Executive Order. (26)

Until recently it was held that a defendant could be held by the government as subject to the Order without oral or written agreement. It seems that in instances where it would be impossible to debar the contractor i.e. where it is the sole source, the federal government has assumed that it may sue on the contract. Although U.S. v. New Orleans Public Service, Inc., (27) the leading case in this area was recently vacated and remanded, it is felt that even if the Executive Order is ultimately judged to require mutual consent and agreement of parties in these circumstances, the decision would probably not be extended beyond public utilities.

In the event that a contractor is found in noncompliance, the Order provides for a variety of sanctions, judicial and administrative. Judicial action may include injunctive relief through the Dept. of Justice. Administratively, proceedings may be pursued which will result in cancellation, termination, or suspension and debarment. These actions must be preceded by efforts to conciliate the areas of disagreement. (27)

Despite the potential effectiveness of debarment and cancellation remedies, these sanctions have rarely been applied. Most recently, Uniroyal and St. Regis Paper were debarred for affirmative action violations and non-cooperation. (Uniroyal was reinstated after a $5.3 million sex discrimination settlement arbitration). The lack of wholesale debarments may be explained in part by the emphasis placed on voluntary compliance through persuasion and conciliation. Although

OFCCP has shown some reluctance to place itself in a position where its authority could be challenged in the past, there is reason to believe there will be more activity in this area since OFCCP feels itself on stronger footing and are therefore more willing to take on large contractors and industries.

Although some commentators have contended that the Order should enable private plaintiffs to bring suit directly against employers for acts of discrimination, such actions have without exception been denied. The only available recourse for individuals is a mandamus action against the governmental agency for failure to enforce the Executive Order as in Legal Aid Society of Alameda County v. Brennan. (28)

Many have questioned the validity of the Executive Order and actions pursuant thereto as a valid exercise of Presidential power, in view of the definition of the scope of that power in Youngstown Sheet & Tube Co. v. Sawyer (29) as strongest when the President acts pursuant to congressional authorization. Subsequent cases have validated congressional approval of these actions under the broad grant of procurement authority granted the President under Titles 40 and 41 of the U.S. Code. It was in the interest of the United States in its procurement procedures to see that its suppliers did not indirectly increase costs and delay programs by discriminatorily excluding available minority workers from the labor pool.

Also, it may be possible to infer congressional ratification for the Order from the congressional record of Title VII. Defeat of several proposed amendments to the Equal Opportunity Act of 1972 which would have reduced the OFCCP authority, may be interpreted as implicit ratification. There is ample reason to believe that Congress was fully aware of OFCCP procedures and did not intend its limitation.

In spite of this implied ratification, many have questioned whether the provisions of Title VII may actually constitute a congressional limitation on the executive power as expressed in the Order. Others have postulated that at times an employer may find himself in a dilemma where OFCCP may require him to take action which may actually place him in conflict with provisions in Title VII. (Specifically §703(j)).

These issues have been raised pre-Weber in the context of third party discrimination complaints in the construction area (hometown plans) and, more recently, by a series of white male plaintiffs charging discrimination in the reverse by the setting of minority and female quotas. Challenges by trade unions against OFCCP minority hiring goals have been defeated on constitutional and statutory grounds. The pre-Weber complaints raised by white males have centered primarily around consent decrees. It has generally been found that Title VII and the Executive Order are to be considered complimentary relying heavily on the similarity in purpose of the two programs. No court at that time required that the party instituting the remedy be the discriminating party nor the program beneficiaries the actual victims of the past discrimination. It was important to have a finding of past discrimination before preferential treatment could be accorded.

The Appellate Court decision in the Weber case began to cast some shadow on the viability of government mandated programs. The arguments which indicated the lower court's view that Congress may look with disfavor on government-mandated affirmative action programs which diminished traditional management prerogatives balanced with arguments that Congress has approved the use of quotas in the past and may be considered to have ratified the Executive Order Program by the 1972 amendments at best leave the situation in an uncertain state.

From a constitutional perspective, the effect of Weber on the Executive Order, while inferred by some, may actually be quite limited or nonexistent. Since Weber did not involve any formal or official government action, the Court did not actually imply any views on whether the Due Process or Equal Protection Clauses of the Constitution might prohibit government actions or requirements based on racial classifications.

While some cases have been based on an interpretation of Title VII rather than a finding of past discrimination, lower court Weber decisions relied heavily on that finding. Many have indicated this to be a dangerous precedent leading to paradoxical results in future cases. While this issue wasn't clearly litigated at the Supreme Court, there is hope that the overall reversal of the opinion may cast doubts on the need for such a finding and resulting inconsistency.

Due to the emphasis on "voluntary" affirmative action plans in Weber, that decision has little impact on affirmative action imposed pursuant to previous consent decrees. In these cases the action taken was in response to a judicial finding of actual past discrimination that must be remedied, or, at least, a judicial finding that the remedies agreed to by the parties are necessary and appropriate in view of the evidence before the court. The use, ab initio, of the judicial process places these actions on a much firmer legal basis than the simple voluntary AAP of Weber.

The status of conciliation agreements achieved through arbitration with government agencies such as EEOC are on a different plane in that such agreements do not have a judicial foundation. Nevertheless, such agreements usually involve at least some initial government finding of past discrimination for which a remedy is necessary, e.g show cause letter. In this regard, they could not be considered as mere attempts to remedy societal discrimination. They too must be considered in a distinct category from the more

generalized government-mandated affirmative action programs designed to promote general racial balance in the work force.

It is at this point that the indicators of the thinking of the various justices in Bakke may prove relevant for future predictions and trends. It would seem that given the present composition of the Court there is at least a majority who favor enforcement of race-conscious affirmative action by the government, but due to Powell's disapproval of quotas and goals, there is probably no majority concensus on how this would best be accomplished, thereby leaving the constitutionality of numerical and statistical devices uncertain.

Some question whether the purposes served by the Executive Order (interest in insuring that all groups in society share equally in employment opportunities created by government spending and remedying the effects of past employment discrimination as demonstrated by severe underrepresentation) may be considered compelling. This will turn on a previous discussion on congressional ratification of the Order. Since a compelling government interest alone is not sufficient justification for the use of racial classifications, the classification must also be necessary in light of the targeted purpose. It is well-documented that less drastic methods of insuring nondiscrimination other than goals and quotas have also met with far less success.

It has also been suggested that Justice Powell, in Bakke, hinted that quotas may be permissible in broader situations than those presented in Weber. One demonstration of this is the apparent approval of construction industry cases. This may indicate the possibility that discrimination exposed through third party claims may be sufficient for quota relief. In any event, there is a trend in OFCCP to make industry-wide finding of discrimination in order to legalize quotas in major industries. The primary focus will be on insurance, energy, and coal mining industries in the 1980's. (30)

New, but as yet unavailable, OFCCP guidelines are incorporating the impact of Weber, and it is anticipated that they will address questions such as:

- What is meant by the term "voluntary"?
- What evidence of discrimination, if any, is needed to trigger the development of voluntary affirmative action?
- Must a federal contractor's voluntary action conform to OFCCP regulations for the development of AAPs, including the use of goals and timetables?
- Is a federal contractor in compliance with E.O. 11246 solely by virtue of its voluntary activity, regardless of the Order's implementing regulations? (31)

Another area which will receive more attention in the future from OFCCP is the role of labor unions in the affirmative action process, particularly where the compliance review demonstrates a problem within the collective bargaining agreement.

FULLILOVE AND OUTLOOK FOR THE FUTURE OF AFFIRMATIVE ACTION

The latest salvo to reach the affirmative action arena is Fullilove v. Kreps, (32) which promises to be this year's Bakke and Weber. In essence, a 10% set-aside for minority business enterprises in the Public Works Employment Act of 1977 was subject to an amendment by Rep. Parren Mitchell (D-Ind.) to the Public Works appropriation bill. It required that at least 10% of the $4 billion provided to state and local governments go to businesses with at least 50% minority ownership. The constitutionality of the Mitchell Amendment is being challenged as a violation of Title VI and the Due Process and Equal Protection Clauses of the Constitution.

Decisions in the lower courts have supported the right of Congress to impose the set-aside provisions to remedy the effects of past discrimination in the construction industry. The District Court in dismissing the complaint said there is probably nothing less discriminatory that Congress could have done to accomplish its objective. These views have been affirmed by the Second Circuit.

Although a decision on what must be considered a moot issue (money already spent) is not expected until June, on the basis on past decisions there is room for speculation on how the Justices will decide the case. There is ample reason to believe that the minority set-aside provisions can be constitutionally justified and rationalized within the constraints already presented in Bakke and Weber.

Since the charges have been framed in terms of Equal Protection and Title VI, the Bakke analysis should be most on point. There seems sufficient justification to believe, due to the significant racial imbalances which exist in the numbers of minority-owned firms particularly in the construction field, that there has been some history of past societal discrimination which has precluded minority businesses from forming and gaining status as well as perhaps some traditional segregation which may have caused the same results. It is possible that the actual beneficiaries of the set-aside provisions may not have been the actual victims of the past discrimination, but this should not be a problem in view of the Detroit Police Ass'n case.

If it can be conclusively proven that there has operated a system of past discrimination, there will be no problem in establishing a set-aside provision to remedy its effects. If, on the other hand, in spite of the imbalances which exist, the Court should be reluctant to find a history of discrimination, the set-aside, in view of Bakke and Weber could still be upheld. If the Justices maintain their previous views, the Brennan group would probably continue to permit the race-conscious decisions, but Powell would probably

still insist on a strict scrutiny test to justify the use of a racial classification (race seems to be the major identifying characteristic of the businesses to be benefited). It could, in that case, be argued that the minority set-aside provision served a compelling state interest in enabling minority businesses to participate more fully and equally in local and state contracts and served to remedy past practices which may have caused the existing imbalances evidenced by the small numbers of such contractors.

Also, a 10% set-aside may also be considered the most reasonable way to accomplish this objective. Ten percent of the contracts amounting to $4 million would place the burden of non-minorities of being dispreferred in .25% of the contracts. In such instances, it is unlikely that the effects would be identifiable upon any one group of non-minority persons and such harm would certainly be minimal.

It would seem that some of the language of Weber would also be relevant in that such a provision should not "unnecessarily trammel" the interests of white contractors, debar them from obtaining future contracts, cause existing contracts to be cancelled, or in any other way displace the gains of existing contract recipients. Additionally, there should be no question as to the temporary nature of the set-aside provisions, in that the funds intended to be affected by that provision have already been spent.

If, ultimately, the Court still found it impossible to find these provisions in consonance with the Equal Protection provisions for granting affirmative action, a set-aside provision would probably be permissible as an affirmative action effort under the Commerce Clause. Certainly the activities of businesses would effect the stream of commerce.

CONCLUSIONS

In spite of a variety of statutory and constitutional challenges, affirmative action remains alive and well and of probably consequence to the decisions of government, private, and public employers for many years to come.

There is ample reason to believe that race-conscious decisions are permissible in both educational and employment settings if such actions do not effect an identifiable group of non-minority persons and do not "trammel the interests unnecessarily" of innocent Caucasians. Such actions buttressed by union support and as a temporary plan to remedy a specific manifest imbalance will meet with the greatest success.

Involuntary affirmative action plans which result from court orders, judicial, or other administrative proceedings, are untouched by Bakke and Weber. In such instances where past discrimination has been so proved, the use of quotas is unquestioned. Voluntary plans as remedies, while on much firmer legal basis, will most likely withstand challenge of reverse discrimination where they have been taken in response to significant statistical imbalance. If the plan is based solely on racial classification, it should be linked to some compelling state interest and considered the most reasonable way to accomplish the desired result.

In spite of the narrow scope of the decisions, these principles will in all likelihood be applied to public as well as private employers; other racial minorities and women as well as blacks. There is no reason at present to believe they will be extended to other white ethnic groups.

The programs administered under Executive Order 11246 as amended have not been litigated as a result of these decisions. Nevertheless, the heads of OFCCP and EEOC have hailed Weber, particularly, as a "green light for affirmative action."

The issues and concerns of EEO and affirmative action efforts cannot be considered lightly or isolated in a vacuum. As one of the mandates which Federal government imposes on private and public employers and one which affects the Federal work force as well, the impact and direction of these programs have a direct bearing on managerial decisions and the manner in which a company will conduct its affairs. Compliance with these regulations by contractors will clearly affect their ability to provide the goods and services desired by procuring agencies. Lack of compliance and an unclear view of the present implications of EEO and Civil Rights law will result in delays, pre-award complications, avoidable litigation, misunderstandings, and resentment.

In short, despite attempts to limit, curtail, and even eliminate its effects by challenges of reverse discrimination, the standard of affirmative action has emerged todate intact, albeit somewhat tattered around the edges.

REFERENCES

(1) 438 U.S. 265, 98 S.Ct. 2733, 57, L.Ed. 2d 750 (1978).

(2) Bakke, 142-4, 145-58, 134-5.

(3) 17 Fair Employment Practice Cases 1095 (No. 77-241).

(4) 47 USLW4549 (May 15, 1979).

(5) 17 FEP 309 (E.D. Mo. 1978) See also Barnett v. International Harvester, 12 FEP 786 (D. Tenn. 1976)

(6) (1978) 18 FEP Cases (BNA) 1379.

(7) (1978) 18 FEP Cases (BNA) 1338.

(8) "Back to Bakke" (1978) 349 FEP Summary, (BNA), 2.

(9) "Reverse Discrimination: What Bakke May Mean to Employers," (1979) 329 FEP Summary (BNA) 6.

(10) Remarks made at Law Journal Press Conference reported in (1979) 349 FEP Summary, (BNA) 3.

(11) 417 U.S.535 (1974).

(12) 427 US 273 (1976). This case involved the retention of a Black employee who had been charged with misappropriation of company property while whites similarly charged were fired.

(13) Ibid.

(14) 401 F. Supp. 175 (N.D. Ill., 1975).

(15) 47 USLW 4851 (June 27, 1979).

(16) Section 703 (a), 42 U.S.C. §2000e-2(a) provides:

(a) It shall be an unlawful employment practice for an employer---1) to fail or refuse to hire ...an individual, or otherwise to discriminate against any individual with respect to his compensation, terms, conditions, or privileges of employment because of such individual's race; 2) to limit or classify his employees or applicants for employment in any way which would deprive any individualof employment opportunities or otherwise adversely affect his status as an employee, because of such individual's race.

Section 703(d), 42 U.S.C. §2000e-2(d) provides: It shall be an unlawful employment practice for any employer or labor organization...controlling apprenticeship or other training or retraining, including on-the-job training programs to discriminate against any individual because his race...in admission to, or employment in, any program established to provide apprenticeship or other training.

(17) Newsnote, "High Court Okays Preference by Race in Voluntary Affirmative Action Plans," Phi Delta Kappan, Summer, 1976, 76.

(18) John J. Gallagher, "The Weber Decision: Summary and Analysis," 6 EEO Today, 235-6.

(19) "Dialogue on Weber and Age Bias," FEP Summary, (BNA), Oct. 25, 1979, 6.

(20) (1979) FEP Summary, (BNA), 6.

(21) 20 FEP Cases 1245(USDC N. Ala., 1979)

(22) 427 US 445 (1976).

(23) Maehren v. City of Seattle, (1979) 20 FEP Cases 854. Also see Shawer v. Indiana University of Pennsylvania, CA3 (1979) 20 FEP Cases (BNA) 816 and National League of Cities v. Dunlop 44 USLW 4974 (196).

(24) Furnco Construction Corp. v. Waters 46 USLW 4966 (1978) and International Brotherhood of Teamsters v. U.S. 431 US 344 (1977).

(25) (CA 6 1979) 20 FEP Cases 1728, 48 USLW 2277 at 2278.

(26) Code of Federal Regulations (CFR), Title 41, Part 60, including:

60-1 general rules applicable under Order
60-2 (Revised Order 4) non-construction contractor affirmative action guidelines
60-3 Testing guidelines
60-20 Sex discrimination guidelines
60-30 hearing procedures for sanctions
60-40 public disclosure of contractor info.
60-50 religious and national origin discrim.
60-60 (Revised Order 14) standardized evaluation procedures for non-construction contractors

See specifically, 60-1.7(a) (1) and (2); 60-1.40 (a) and (b); 60-1.20(d); and generally, Revised Order 4 and 14.

(27) 553 F2d 459, 14 FEP 1734 (5th Cir 1977), vacated and remanded ____US____(1978).

(28) 381 F. Supp. 125 (N.D. Cal. 1974).

(29) 343 US 579 (1952).

(30) Gallagher, 238-9.

(31) "Future for Federal Contractors" (1979) 384 FEP Summary (BNA) 4.

(32) 584 F2d 600 (2nd Cir. 1978). Also 48 USLW 3365 (1979) or Supreme Court arguments.

SOCIO-ECONOMIC IMPLICATIONS OF THE DEFENSE BUDGET AND MULTIPLE-YEAR PROCUREMENTS

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ABSTRACT

The last decade has witnessed shifts in national priorities between military spending and civilian programs. The downward trend in defense spending that began in 1968 was halted in 1976; however, increases since that time have hardly been significant. Moreover, as the defense budget began to grow in the late 1970s, huge sums were required in order to modernize existing weapon systems and facilities. Little has been left for the development of new systems or additional research. Despite this, the defense budget remains the most controllable portion of the federal budget for purposes of fiscal control and stabilization. Therefore, the socio-economic implications of the defense budget are vast and widespread, especially when the "multiplier-effect" of the defense dollar is considered. The purpose of this study is to briefly review the recent trend in the defense budget, weigh the socio-economic implications, and suggest changes that would make the use of multiple-year procurements more effective and beneficial.

THE RECENT TREND

The defense budget has declined sharply, as compared to total federal spending since 1968.

Budget Outlays — Constant 1981 Dollars - FIGURE 1

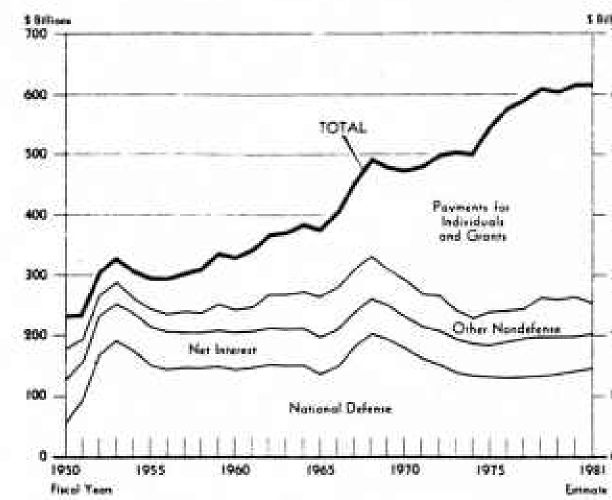


Figure 1 shows how budget outlays have diminished since that time in constant 1981 dollars. For example, in 1968 National Defense comprised 41.8% of the total federal budget. As the Vietnam War slowed, the Defense portion fell to less than 23% in 1976. Table 1 shows the significant

TABLE 1
THE BUDGET FOR FISCAL YEAR 1981

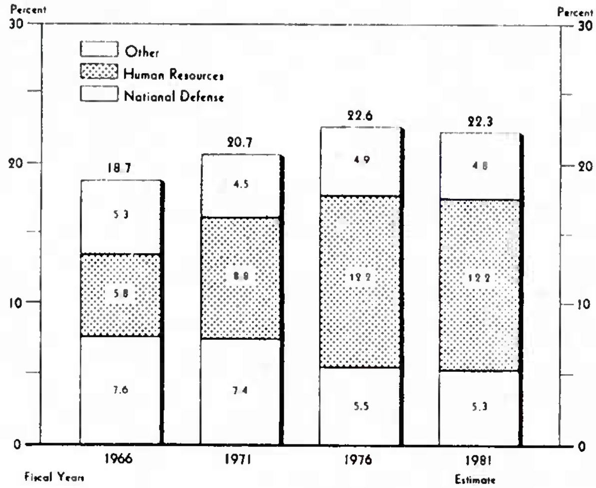
BUDGET OUTLAYS BY LARGER CLUSTER AND BY FUNCTION, 1956–76
(in billions of dollars)

	Actual				
	1956	1961	1966	1971	1976
National defense [1]	**39.7**	**46.6**	**54.9**	**75.8**	**89.4**
Human resources:					
Income security	9.9	21.4	28.9	55.4	127.4
Social security	(5.5)	(12.2)	(20.2)	(35.2)	(72.7)
Other	(4.4)	(9.3)	(8.7)	(20.2)	(54.7)
Health	.4	.9	2.6	14.7	33.4
Education, training, employment, and social services	.6	1.1	4.4	9.8	18.7
Veterans benefits and services	4.9	5.7	5.9	9.8	18.4
Subtotal, human resources	**15.7**	**29.1**	**41.8**	**89.8**	**198.0**
Net interest:					
Interest	6.3	8.1	11.3	19.6	34.5
Interest received by trust funds	−1.2	−1.4	−1.9	−4.8	−7.8
Subtotal, net interest	**5.1**	**6.7**	**9.4**	**14.8**	**26.7**
All other:					
International affairs	2.4	3.2	5.6	4.1	5.6
General science, space, and technology	.1	1.0	6.7	4.2	4.4
Energy	.2	.5	.6	1.0	3.1
Natural resources and environment	.9	1.8	2.7	3.9	8.1
Agriculture	3.5	2.6	2.4	4.3	2.5
Commerce and housing credit	.5	1.2	3.2	2.4	3.8
Transportation	1.4	4.0	5.7	8.0	13.4
Community and regional development	.1	.3	1.1	2.9	4.8
Administration of justice	.3	.4	.6	1.3	3.3
General government	.7	1.2	1.4	2.0	2.9
General purpose fiscal assistance	.1	.2	.3	.5	7.2
Undistributed offsetting receipts (except interest)	−.3	−1.0	−1.7	−3.7	−6.9
Subtotal, all other	**9.9**	**15.3**	**28.6**	**31.0**	**52.3**
Total budget outlays	**70.5**	**97.8**	**134.7**	**211.4**	**366.4**

[1] The national defense function

changes in federal spending in a more detailed manner, showing significant changes in the budgets of other departments of the federal government. The defense budget has also continued to diminish when compared to GNP as shown in Figure 2. Major changes in defense spending relative to the economy have occurred over this period. In 1966, the first year of major U. S. combat involvement in Vietnam, national defense spending was equal to 7.6 percent of GNP. Defense spending

Budget Outlays as a Percent of GNP - FIGURE 2



rose significantly faster than the national economy in the next two years, peaking at 9.5% in 1968. Defense outlays are up 93% between 1971 and 1981; however after adjustment for inflation, have declined by 10%.

The impact of this trend has been severe to Department of Defense. The decline in the defense budget has resulted in a smaller number of contractors willing to undertake major military programs. For example, a study performed by the Air Force for the Aircraft Landing Gear industry showed a startling trend in short-term industrial capability.(1) During World War II, several contractors produced aircraft landing gears in large quantities. Since then, however, declining requirements and intense competition has eliminated all but three contractors currently producing the product. The study went further to state that in 1969 there were over 6,000 contractors in the aerospace industry. This number included not only prime contractors, but second and third tier suppliers. The large drop in military procurements that took place after the Vietnam war affected the subcontractor group significantly. As a result, only about 4,500 prime and subcontractors remained active as of 1976. Those who have remained devote less of their capacity toward military programs. The report went on to state that no one has entered the design and manufacturing of large and medium sized landing gears in the past twenty-five years and survived.

The situation encountered in the landing gear industry is apparent of a trend found in many of the major military items. The Air Force study cited many reasons for this trend, a number of which are as follows:

- Huge expenditures are required for material, machine tools, and test equipment.
- Major military items differ from related commercial products in many areas. Higher strength alloys are usually required and rather large and complex forgings are often used.
- Complex shapes require expensive and often exotic machine tools.
- Expensive test equipment must be obtained and maintained--even those infrequently used.

As resources have become more scarce and military requirements more complex, prices and manufacturing leadtimes have grown at an astounding rate. The slogan "do more with less" has become the motto of the Defense Department.

SOCIO-ECONOMIC IMPLICATIONS

The defense budget continues to have a strong impact on the socio-economic environment of our nation even though it has diminished as a portion of the federal budget. The Department of Defense employed 885,990 military personnel and supportive civilians in 1979. This accounted for almost half of all persons employed by the Federal government for that year. The additional estimated 1.5 million workers in defense-related industries is a very significant portion of our nation's total workforce. Not only is the defense budget a strong factor in directly determining the rate of unemployment, it also is a powerful tool in other ways for the purpose of fiscal control and stabilization. During an inflationary period, heavy reliance on taxation as a major fiscal device is limited by conflicting needs. On the other hand, inflation can be diminished by reduced spending.

Planned spending is a crucial force in determining the level of national income, therefore, it is a means of controlling unemployment. Lower expenditures by the federal government have a contractionary effect, lowering production output and employment. Increased government purchases therefore have an expansionary effect, increasing employment and output. If there is a slack in the economy, increases in government spending will usually cause output to rise. If the economy is at or near full employment, however, any increases will cause prices to rise and inflation. Relatively small changes in government spending can have a great influence on the economy when the "multiplier effect" of the defense dollar is considered. The federal government exerts great influence on total spending and output through its expenditures and tax policies.

In relation to the balance of the federal budget, the defense portion is clearly the most controllable. Outlays in any one year are considered to be relatively uncontrollable when the program level is determined by existing statutes, contractual requirements, or other obligations. Therefore, the bulk of civilian programs are considered to be rather uncontrollable because often little can be done to alter the effect of these obligations without amending existing legislation. For example, the definition of a beneficiary eligible for programs like social security and medicaid is established by law and therefore can only be altered by changing the law. Budget authorizations that exceed one year result in what is called a "lock-in" effect. Implemen-

tation of fiscal control and discretionary changes is hampered. Table 2 shows the relationship between national defense and the balance of the federal government in relation to the controllability of outlays for 1979.

TABLE 2

RELATIVELY UNCONTROLLABLE OUTLAYS FOR 1979

(In billions of dollars)

Relatively uncontrollable under present law	January 1978 estimate (existing law)	Change	Actual
Open-ended programs and fixed costs			
Payments for individuals:			
Social security and railroad retirement	107.8	−1.1	106.7
Federal employees retirement and insurance [1]	29.0	.9	30.0
(Military retired pay)	(10.1)	(.2)	(10.3)
(Other) [1]	(18.9)	(.8)	(19.7)
Unemployment assistance	11.8	−1.1	10.7
Medical care	42.1	−.5	41.6
Assistance to students [1,2]	2.7	.1	2.8
Housing assistance	4.3	−*	4.2
Food and nutrition assistance [2]	8.6	1.2	9.8
Public assistance and related programs [1,3]	16.5	−.1	16.4
All other relatively uncontrollable payments for individuals [1]	2.0	.7	2.7
Subtotal, payments for individuals	225.0	−.1	224.9
Net interest	39.9	2.7	42.6
General revenue sharing	6.9	−*	6.8
Farm price supports (CCC)	4.5	−.8	3.7
Other open-ended programs and fixed costs [1]	9.5	−1.5	8.0
Total, open-ended programs and fixed costs	285.8	.3	286.1
Outlays from prior-year contracts and obligations:			
National defense	33.8	−2.9	30.9
Civilian programs	55.7	−6.6	49.1
Total, outlays from prior-year contracts and obligations	89.5	−9.5	80.0
Total, relatively uncontrollable outlays	**375.3**	**−9.2**	**366.1**

*$50 million or less

[1] This subcategory now contains elements that were previously classified in the veterans benefits grouping

[2] This is a new subcategory within payments for individuals

[3] Revised to treat earned income credit payments in excess of the tax liability otherwise owed as outlays instead of tax refunds

Relatively uncontrollable outlays are grouped into two major categories:

- Open-ended programs for which outlays are generally mandated by law.
- Prior-year contracts for which outlays are required by previous actions such as contractual obligations.

Open-ended programs consist mainly of benefit programs, subsidies, and grants for which eligibility is automatic or fixed by law.

Total budget outlays for 1979 were approximately 74% uncontrollable. The defense portion of these uncontrollable outlays was only 8%. Therefore, it is not surprising that when Congress attempts to respond to public pressure to economize, the result is often a squeeze on military spending. No other portion of the federal budget compares in terms of controllability as shown in Table 3.

Table 3 - Percent Distribution of the Controllable Portion of the 1979 Budget

Defense	68
Health, Education & Welfare	9
Treasury	5
Agriculture	4
All Others	14

The defense budget, therefore, is the main tool used by Congress to implement discretionary fiscal policy. The economy and the budget are interrelated and discretionary changes must be available. Economic conditions significantly affect the budget and the budget, in turn, influences economic conditions. Inflation has been the single most serious problem recently encountered by our nation. Accordingly, restraint in federal spending has been encouraged. Therefore, as last minute funds are needed for other programs, they have often been diverted from the defense budget.

THE OUTLOOK

The effect of current budget changes extends far beyond the current budget year. They establish program trends that have important influence on the size and composition of budget for years into the future. For this reason, budgets have presented projections extending four years beyond the current budget year since 1970. Such budgeting requirements will force all federal decision-makers to develop current budgets in terms of long range goals and constraints to ensure that the future impact of current year decisions is understood. The gradual phase-out of old programs can be coupled with the development of new programs. As a result, outlay estimates for the first two years beyond the budget year now receives explicit policy review and represent tentative planning targets. Figure 3 provides an estimate of the required budget authority anticipated for the Department of Defense through 1983.

FIGURE 3

National Defense Programs (Budget Authority)

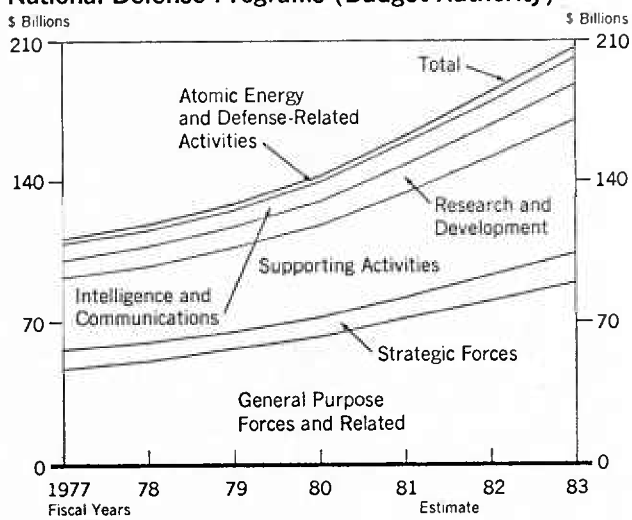


Table 4 shows the estimated and projected defense budget outlays as compared to the balance of the federal budget. Budget outlays are projected to increase by $286.9 billion between 1981 and 1985. Nearly half of the 1981-1985 projected outlay is relatively uncontrollable, approximately $131.5

TABLE 4 PERCENTAGE COMPOSITION OF BUOGET OUTLAYS

Description	Actual			Estimate			Projection	
	1967	1973	1979	1981	1982	1983	1984	1985
NATIONAL OEFENSE:								
Direct Federal payments lor individuals	1.2	1.8	2.1	2.2	2.3	2.3	2.3	2.4
Other	42.0	28.4	21.7	21.5	21.8	21.7	22.4	23.1
Subtotal, national defense	43.1	30.2	23.8	23.7	24.1	24.0	24.7	25.4
NON-OEFENSE:								
Direcl Federal payments for individuals	24.1	35.5	40.3	43.0	42.5	44.5	44.6	45.1
Payments for individuals through States and localities	3.1	5.8	5.8	6.1	6.1	5.9	6.0	6.1
All other grants to States and localities	6.5	11.1	10.9	9.5	9.2	8.6	8.1	7.7
Net interest	6.5	7.0	8.6	8.8	7.9	6.8	6.2	5.7
Other	16.7	10.4	10.5	8.8	10.2	10.2	10.3	9.9
Subtotal, nondefense	56.9	69.8	76.2	76.3	75.9	76.0	75.3	74.6
Total budget outlays	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

billion. Outlays for open-ended programs (non-defense) are estimated to comprise 59% of the budget in 1981, declining to a projected 55% in 1985. Outlays for defense related uncontrollable obligations is expected to be an additional 15 to 18 % of all such outlays. Therefore, the use of the defense budget as a fiscal tool will be slightly diminished.

Figure 4 indicates that the increases projected for future years will be needed mainly to update and maintain general purpose forces and supporting activities. Slight increases in the expenditures for research and development projects along with improvements in our strategic forces are forecast. The future facing defense executives is not as dismal as encountered in 1968 but none the less it is still quite challenging. Improved efficiency, reduced costs, and increased productivity are essential to ensure that more resources are available to improve combat capabilities. Greater competition must be encouraged in contracting. The purchase of commercially available goods and services must continue to be evaluated. Improvements in supply management and the disposal of excess stocks will also require further investigation.

MAJOR DEFENSE PROCUREMENTS

The balance of this study will be an investigation of a proposed improvement in the purchase of major weapon systems when procurements are made through the use of multiple-year contracting. It should be noted that an increase in the use of multiple year contracts is not encouraged. Their use should continue to be made only in those situations where they are most effective. Instead, a method in which to make such procurements more effective, socially, and economically beneficial will be suggested. The main emphasis of the Department of Defense in procurement management is to select weapon systems that will be affordable and effective over a long period of time. New programs are designed for economy not only in the initial production stages, but throughout the complete life cycle of the product. Continued improvements in procurement management will result in fewer false starts and costly terminations.

Coupled with the recent and continued improvements in defense procurement planning, advances can be made in the method of contracting for these supplies. One need only to review DAR 1-322 to see the many benefits realized from the use of multiple-year procurements, the main benefits being:

- Lower costs
- Greater competition
- Improved production efficiency and quality
- Lower administrative costs
- Stabilization of the workforce

Lower costs are obtainable due to the ability to order large quantities. It is inherent, therefore, that this type of procurement requires the ability to adequately project future requirements. Competition is increased because industry is more willing to bid for such procurements. Any price advantage of a firm currently in production is minimized because the substantial capital investment required is distributed over a larger number of units. Lower prices are obtained as firms that were previously unable or unwilling to compete, enter the market.

Multiple-year procurements also help to ensure that high quality products are obtained. Contractors have a greater ability to recruit and retain highly skilled personnel with the assurance of longer periods of employment. Contractors also enjoy the ability to vary production rates during the off-peak periods, which results in further cost savings. Improved efficiency and quality benefit not only the Government, but the contractor as well.

Multiple-year procurements result directly in other benefits to the Government. Since the number of contracts is reduced, the administrative burden in the analysis, negotiation, and placement of orders is reduced because duplication is minimized. Smaller businesses are able to compete for multiple-year procurements since the high initial production costs are offset by continued production. There is no substitute for competition to ensure that defense dollars go further.

These benefits are greatly diminished, however, when a prospective contractor takes a closer look at a proposed multiple-year contract. The main problem being that the authority to issue multiple-year contracts is not matched with guaranteed concurrent appropriations obligated for the future. The federal budget is subject to annual review and approval. Many changes are implemented in the interim to reflect shifting national priorities.

The resultant problem faced with multiple-year procurements is the risk assumed by the contractor in setting up for large quantity, multiple-year production of items that may be

cancelled at any time in the future. All multiple-year defense contracts are required by DAR to be subject to a $5 million cancellation ceiling. In today's environment, most prospective contractors realize that such a low ceiling will cover only a very small portion of the sunken costs initially required to begin production. The cancellation ceiling, in effect, is forcing contractors to "buy-in" during the early production period. This practice, although discouraged by regulation, is actually encouraged by the present budgetary process. The threat of cutbacks or even complete cancellation is ever present. A significant increase in competition can be brought about only through reducing this great risk to the contractors. The present method of annualized budgeting severely hampers such competition. Presently, only large, well established defense contractors can afford to take on most additional defense programs. This situation has had an adverse impact on production leadtime. Projects must be either dropped completely or the acquisition cycle is lengthened making the final product more expensive and often less effective. Many useable and necessary military programs are caught within the "funding bow wave."

Multiple-year authorizations with guaranteed future appropriations is not expected in the near future. Such a change would require revision to the Constitution and be subject to much debate and litigation prior to that change. An improvement that could be implemented in a relatively short amount of time would be the lifting of the present cancellation ceiling to an amount more reflective of the great burden assumed by the contractor. The additional cost to the Government for such action, in terms of dollars and additional uncontrollability, would undoubtedly be offset in the long run through an increase in competition alone. The socio-economic well-being of our nation will be strengthened.

CONCLUSION

Improved planning and requirements forecasting is a goal toward which the Department of Defense is constantly striving. The importance of the defense budget as a tool for fiscal control and stabilization cannot be ignored, yet a stable level of defense spending will serve both national security and the economy. Programs designed toward affordability will reduce the need for numerous annual budget changes. Improvements are sorely needed in the Congressional budgetary process, however, such changes cannot be expected in the short-term. The use of multiple-year contracting is counter-productive due to the restriction placed upon such procurements by Congress. The continued use of a multiple-year budget planning process will help promote more conscious forward planning by Congress. The social and economic responsibility for better management rests not only with Defense executives, but with the members of Congress and the Office of Management and Budget as well.

REFERENCES

(1) "Statement of Work for Landing Gear Industry Capacity Study," Air Force ASD/PPR March 25, 1976.

Note: All figures, tables, and dollar values were taken from "The Budget of the United States Government - 1981."

MAJOR STEPS IN A COST COMPARISON STUDY/CONTRACTING OUT FOR SUPPLY SERVICES AT PATRICK AIR FORCE BASE, FLORIDA

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Directorate of Contracting and Support

ABSTRACT

This file documents the major steps required to obtain commercial resources to manage and operate the Standard Base Supply System (SBSS) at Patrick Air Force Base, Florida. All documents are chronologically sequenced to provide Air Force and Department of Defense personnel with a detailed and comprehensive guide for transitioning from in-house to contracting-out services. It is being made available DoD-wide because it is the only known source document that "pulls together" all the tasks required to initiate and complete the contracting-out transition process.

INTRODUCTION

A government file is now available which documents all the tasks required to initiate and complete the "Contracting Out" transition process. The file is entitled "Major Steps in A Cost Comparison Study/Contracting Out for Services at Patrick AFB, Florida". This file details 42 major steps leading to the utilization of commercial resources to manage and operate Patrick's Standard Base Supply System (SBSS). All documents contained in the file are chronologically sequenced. The file is primarily intended as a guide for Air Force and DoD contracting personnel. However, other government departments and agencies may also find the file useful. Academicians will also find this file useful as a primer for further research and analysis of procedures, cost comparison studies, socioeconomic impacts and other functions of the Contracting Out process as prescribed by OMB Circular A-76. Copies of the file may be obtained from the:

Air Force Business Research Management Center (RDCB)
Area B, Bldg 125
Wright-Patterson AFB, Ohio 45433
Area Code 513-255-6221
AUTOVON 785-6221

BACKGROUND

In 1974 studies were initiated at Patrick AFB to determine the feasibility of Contracting Out the Standard Base Supply System (SBSS). These studies dealt with comparative cost analyses, environmental impact assessments, the phase-out of military and civilian personnel and Department of Labor wage determination data -- all in addition to the myriad of documentation and planning required for the acquisition of a multimillion dollar system/service.

By the summer of 1977 all the studies were completed as prescribed in OMB Circular A-76 and AFM 26-1. Contract award was tentatively scheduled for late summer 1977. Twenty-seven firms were solicited. Five proposals were received and negotiations were conducted with four responsive offerors. Raytheon Service Company, the low offeror, would have been awarded the contract. However, the contract was deferred as a result of Congressional restrictions imposed by Section 852 of the FY 78 DoD Appropriation Act.

In October 1978, Patrick AFB was again ordered to initiate a new cost comparison study of the SBSS. Other previous studies were either updated or revalidated. In March 1979 solicitations were issued to 46 firms, five firms responded and on 11 July 1979 a $3.2M(1 year) Fixed Price Incentive (with Firm Targets) Contract was awarded to Pan American World Airways (PAA).

The contract was awarded to a commercial firm because the Cost Feasibility Study versus the contractor's bid reflected that a contractor could manage the SBSS at less cost than the USAF.

COST COMPARISON STUDY

A Cost Comparison Study was required on this contract because it was a "NEW START". A "NEW START" is when an activity has been reviewed and approved to conduct a Cost Study to determine which is more economically feasible -- in-house (Civil Service/Military) vs Contractor. The guidance for conducting a Cost Comparison Study (Manpower Division is the OPR) is in OMB Circular A-76 and AFM 26-1. The Dollar Value of the Cost Comparison results vs the contractor's bid, determines whether the operation in question will be Contracted Out or remain in-house (i.e. with the Government).

DIFFICULTIES ENCOUNTERED

Some of the major problems encountered at Patrick AFB during the contracting out process included:

a. Finding new jobs for 199 Civil Servants.

b. Finding new locations for 106 military personnel.

c. Encumbered employees being given first refusal of the job with the new contractor.

d. The Contractor's inability to determine the composition of his work force until the last day before transition.

e. Contending with socioeconomic controversy.

f. Difficulties in accomplishing the Base Supply mission.

LESSONS LEARNED

Lesson Number 1. Establish a highly technically qualified individual/functional staff to implement the contracting out study. The individual/staff should be assigned outside the effected activity, preferably to the contracting organization.

Background. Typically, individuals not having the technical competence or prior experience/training have to be employed on an ad hoc basis. This has caused delays, inadequate completion of tasks and has subjected DoD to adverse criticism/controversy and congressional inquiries.

Lesson Number 2. There should be a firm commitment on the part of the displaced Civil Service Employee as to whether or not he will accept employment with the winning contractor.

Background. In the early stages of performance of the Patrick AFB Supply contract, recruiting difficulties were encountered by the contractor. Some of these difficulties relate to the offering of jobs to displaced civil service workers, the acceptance of jobs offered and then during the final days before start of performance by the contractor, declination of the jobs. This change of mind by a significant number of skilled workers during the final stages of preparation for performance of the contract impacted the contractor's ability to perform, since there was insufficient time remaining to recruit other skilled workers.

Lesson Number 3. More detailed criteria should be provided in AFM 26-1 in order to more efficiently perform a Cost Comparison Study.

Background. The AFM 26-1 should be expanded to address the following issues which have proved controversial in the past:

a. Cross-utilization of personnel.

b. The establishment of firm deadlines early to aid in reducing the number of personnel to be potentially separated.

c. Establishment of comparable manpower factors to realistically equate the cost benefits of retaining government employees vs the contracting out function to be performed.

d. How to provide contractor access to Civil Service Employees for the purpose of offering employment between contract award and take-over dates.

e. Detailed criteria/guidelines on how to equate military positions to Civil Service classifications (i.e. job descriptions).

Lesson Number 4. Allow adequate time and recognize costs for Contractor phase-in.

Background. If too little time is provided to a contractor for phase-in prior to take-over, inadequate interfaces result. If too much phase-in time is provided, conflicts may arise between disgruntled Civil Service Employees and Contractor Personnel. Above all, phase-in costs should be a mandatory part of the offerors proposal. A contractor who does not bid phase-in cost in order to get the award will "cut corners" during this period.

NEED FOR FURTHER RESEARCH

1. Statement of Problem

a. A need exists for more detailed guidance for cost comparison studies and contracting out for services within USAF/DoD.

b. It has been noted that different contracting activities within USAF/DoD procure similar services in widely differing fashions. Specifically, there is often no uniform approach to describing the services to be rendered, selecting the contract type, recognition and application of statutes and regulations unique to service contracts, and establishing procedures for administering services contracts. The problem becomes more acute as USAF/DoD enters into an era of

contracting out operation and maintenance functions currently being performed by government employees.

2. Recommended Research Approach

a. This effort could be accomplished with in-house resources or in conjunction with contract sources on an expert and consultant basis, in order to obtain qualified opinions from outside the government.

b. In conducting the study it is recommended that the major "types" of services contracts be identified and segregated (e.g. janitorial, food services, base operation and maintenance, research and development, contracts for communication services, etc.) into major categories. Within these categories, examples of statements of work (SOWs) and appropriate contract types should be identified. This portion of the study would require review of other DoD agency contracting practices and SOW drafting techniques. From this study, model contracts complete with rationale and discussion of alternative approaches should be developed. Enforcement and incentive techniques should be considered and discussed. Weaknesses in recommended approaches should be anticipated and identified. Also as part of this study, the various statutory and regulatory requirements unique to service contracts (or with unique applications) should be identified. The compliance of DARs should be reviewed in order to assure that coherent guidance is being provided. Further, the model contracts developed should identify statutes and regulations with potential application.

c. The end result of this study should be a series of model contract types designed to guide procuring activities toward uniform approaches. It should not impose mechanistic "boilerplate" strategies upon the contracting activities. It is essential that rationale be discussed and alternative approaches identified for meeting identified service contract requirements.

3. Time Visibility. This study would in all probability exceed one year in duration. In reality, it could best be handled as an initial intensive study with continuing update at a reduced level of effort.

4. Quantitative and Qualitative Pay-Offs. As a result of this study, Regulations could be updated and services contracted for in a more uniform, cost effective, and enforceable fashion. The specific cost savings resulting from improved practices cannot reasonably be quantified at this time.

CONCLUSION

The objective of Contracting Out is to reduce costs and increase efficiency through the use of the free enterprise system. Contracting Out is a DoD policy which is used by other Government Agencies in various degrees. It is a relatively new policy but it is increasingly being implemented by other services within the DoD. As in the implementation of any other new program, problems do arise. However, there is no need to entirely re-invent the wheel; this is why the file was developed. It, in itself, is only a guide because every acquisition is unique. More research is needed, especially in developing cost comparison models and in the latter stages of the Contracting Out process.

P. L. 95-507 — A New Focus

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and
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Department of the Interior

ABSTRACT

This article concentrates on a significant improvement in small business contracting by the Government brought about by the new Amendments to the Small Business Act of 1978, P.L. 95-507. A shift in direction has occurred which considerably enhances the long-term effectiveness of the entire program by providing a greater opportunity for private enterprise to offer on-the-job assistance to small and small disadvantaged businesses. The paper emphasizes certain provisions of P.L. 95-507 and recommends changes to improve the program. It also briefly looks beyond government to commercial contracting to show the full scope of technical assistance.

INTRODUCTION

The purpose of this paper is to evaluate the new opportunities available to small businesses and small concerns owned and controlled by socially and economically disadvantaged group members as a result of the new Amendments to the Small Business Act of 1978, P.L. 95-507. This is not intended to be a thorough treatment of this vast new area. It is intended only to highlight some of the major provisions of the Act, and to focus on some of the problem areas that have been detected by both federal contracting agencies and private contractors. The major portion of this paper, however, will deal with what the authors consider to be a major problem area in the small and small disadvantaged contracting sphere - that of a need for more technical and management assistance to small business by the private sector. We believe that P.L. 95-507 provides a new focus in Government contracting which will promote the long-term viability of small and disadvantaged business concerns through the more active participation of private enterprise. We do not intend that this paper be construed as an attempt to cast the federal government's present effort in this area in a negative light because we recognize that considerable progress has been made. It is our intention, however, to provide some insight into where we may need to go in the future if we are to continue to service the needs of this very important segment of our business community.

Until the passage of P.L. 95-507 on October 15, 1978, there had been no specific statutory coverage, or recognition of, federal procurement from minority businesses. Executive Order 11625, enacted on October 13, 1971, did authorize the Secretary of Commerce and department and agency heads to develop "compliance plans and specific program goals for the minority enterprise program." However, this program was inadequate in guaranteeing a meaningful proportion of government contracting dollars for small business concerns. In addition, small and minority businesses were not making progress in terms of gross sales as compared to large non-minority firms. For example, in 1977 if we were to add the gross sales of the nation's top 100 minority businesses, their gross sales would rank only 225 on the Fortune 500 listing. Aside from this, the viability of small business concerns relates directly to job opportunities for millions of Americans since small and minority firms employ a large portion of all employed persons in the country. In addition, the effective performance of these businesses is crucial to the well-being of the free enterprise system. To insure the survival of this very important segment of our business community, Congress enacted P.L. 95-507.

SLOW GOVERNMENT ACCEPTANCE

Since the passage of P.L. 95-507, the federal government has been slow in implementing the Act and including its requirements in agency contracts. Two recent Congressional inquiries, for example, indicated that several agencies had violated the requirements of this new Act by awarding more than $140 million in contracts without the required provisions of section 211 that mandate subcontracting opportunities for small and small disadvantaged businesses. Whether this slow start-up by federal agencies is the result of large bureaucracy, inefficiency, problems of attitude or vague regulations, this legislation goes a long way toward correcting a number of problems that the old 8(a) program has caused both small business and federal contracting

agencies. Problems such as limited technical and management assistance opportunities to small businesses, and the argument of excessive prices of 8(a) contracts, should be eliminated. Let's examine key provisions of the Act in an effort to ascertain the advantage that can be realized by both small business and the federal government if P.L. 95-507 is aggressively implemented.

KEY PROVISIONS OF THE ACT

Although P.L. 95-507 contains many provisions that span from allowing SBA to guarantee performance bonds for small and disadvantaged business to the establishing of Offices of Small and Disadvantaged Business Utilization within each federal contracting agency, this section of the paper will concentrate only on the major contracting provisions required by the Act.

The 8(a) program which has been the center of much public attention and criticism was until the passage of P.L. 95-507 based upon the general statutory language which created the Small Business Administration and authorized it (SBA) to enter into contracts with federal procurement agencies and subcontract their performance to "small business concerns or others." However this provision made no mention of contracting with disadvantaged firms.

The new Act provided clear statutory legitimacy to the 8(a) program and provides specifically, for the first time, that the SBA may subcontract to "socially and economically disadvantaged concerns" federal procurement contracts for services, construction and supplies. For those not familiar with the terminology, socially and economically disadvantaged concerns are those owned by socially and economically disadvantaged individuals. "Socially disadvantaged" individuals, under the act, are those who have been subjected to racial or ethnic prejudice or cultural bias because of their identity as a member of a group without regard to their individual qualities. "Economically disadvantaged" individuals are "those socially disadvantaged individuals whose ability to compete in the free enterprise system has been impaired due to diminished capital and credit opportunities as compared to others in the same business area who are not socially disadvantaged."

Probably the most important section of the new act is section 211 which amends section 8(d) of the original Small Business Act. This section requires that a low bidder or low offeror on a federal contract (more than $1,000,000 for contracts for construction and over $500,000 for all other contracts) submit, prior to award, a subcontracting plan. This plan is to include percentage goals for the utilization of small business concerns and small business concerns owned and controlled by socially and economically disadvantaged individuals. A prime contractor must also delineate the effort that will be taken to ensure that small business firms have the maximum practical opportunity to compete for subcontracts under this contract. It is important to note that this section provides different requirements for contracts awarded under procurements by negotiation and for those awarded as a result of formal advertising. For negotiated contracts, the act requires that the successful offeror "negotiate with the procurement authority a subcontracting plan" which will provide for percentage goals for both small and small socially and economically disadvantaged concerns. This section is further buttressed by the provision that states "that no [negotiated] contract shall be awarded to any offeror unless the procurement authority determines that the plan to be negotiated by the offeror provides the maximum practicable opportunity for small and small disadvantaged concerns to participate in the performance of the contract. Failure of the contractor to comply with this plan "in good faith" is a material breach of contract.

Although this material breach provision as well as the requirement for incorporation of the plan in the contract are applicable to both negotiated and advertised contracts, there is no provision in the act for advertised contracts which requires either negotiation of the plan between the parties or a pre-award determination by the government. The absence of such a requirement has caused much concern among advocates for this Act. There is an intention by many groups to recommend to Congress that this requirement be extended to advertised contracts. This proposal will be discussed in more detail in another section.

Section 211 also authorizes federal agencies, in instances of negotiated contracts, to provide appropriate incentives to prime contractors to encourage subcontracting opportunities to small and small disadvantaged firms, commensurate with the efficient performance of the contract. This provision, as implemented by OFPP, will likely promote a more voluntary response from industry because it provides a profit motive. Prime contractors are encouraged through higher profits to increase their established goals for small and disadvantaged business concerns.

Section 204 of the Act authorizes SBA to provide financial assistance to public or private organizations to pay all or part of the cost of projects designed to provide technical or management assistance to individuals or enterprises eligible for assistance under the Act.

The thrust of all these provisions, unlike 8(a), is to encourage private industry to provide direct oversight to small and disadvantaged business. The Government now looks to the prime contractor as the responsible party for the entire contract performance of small and disadvantaged business. Thus the prime contractor must provide the necessary training and assistance to ensure total performance.

ESCALATE AND EMPHASIZE THE PRESENT SUBCONTRACTING PROGRAM

Although the 8(a) program has historically provided an impetus to the Federal Government to involve small disadvantaged businesses in its government contracting, it is not equipped to fully satisfy the need for technical and management assistance, nor does it provide a fully satisfactory method of assuring a reasonable price for the government. The technical assistance is provided by either the Government directly or through a Government contractor, which is not the ideal circumstance for on-the-job assistance. Price becomes a problem because of the uncertainty created between Government and the disadvantaged contractor because of the noncompetitive atmosphere and the difficulty of justifying the price. This situation also tends to increase the procurement lead time. What was needed in this regard was a mechanism to insure both a reasonable price for small business contracts, and the involvement of an entity capable of providing technical assistance -- the private sector. Both problems are satisfied by the subcontracting requirements of P.L. 95-507.

The subcontracting clause requirement and the incentive provision, both authorized by section 211 of the Act, encourage the involvement of private industry with small and small disadvantaged businesses.

As previously discussed, the Act requires the inclusion of a subcontracting plan by a low bidder or successful offeror in all government contracts over $1,000,000 for construction and $500,000 for other contracts. This plan, which applies to both negotiated and advertised contracts, must set forth percentage goals for the subcontracting of small and small disadvantaged businesses. The essential effect of the goal requirements of advertised and negotiated procurement is to encourage prime contractors to increasingly utilize small and disadvantaged businesses. Although negotiation of an acceptable goal is not provided for in advertised contracts, the goal is negotiated with the accepted offeror in negotiated contracts. However, the net effect should be an added emphasis on such subcontracting. Informal discussion with representatives of a major contractor association indicates they are supporting the submission of such goals by their members as a meaningful aid to small and disadvantaged businesses. They were quick to state that they support a goal program for grants. They consider the approach of a program like Section 211 of P.L. 95-507 to have the additional advantage of uniformity, unlike current grant programs.

Technical assistance is assured because the Government prime contract holds the prime contractor accountable for the subcontractor's performance. A prime contractor, then, will monitor and in some cases even assist the subcontractor through technical input in his performance, since he is intensely interested in the outcome of the overall contract. Small businesses that are given this technical input will be receiving a resource that will enable them to perform better on future subcontracts and even qualify for prime contracts ultimately. P.L. 95-507 introduces perhaps the most effective technical assistance, on-the-job training.

The incentive provision, also found in section 211, is designed to benefit small and disadvantaged subcontractors by appealing to the profit motive of prime contractors. This incentive provision provides, with respect to negotiated procurements, a mechanism by which federal agencies may increase a prime contractor's profits when the contractor exceeds the subcontracting plan. This clause benefits both the contractor, through increased profits, and small businesses, by providing more businesses an opportunity to work with the contractor and benefit from his expertise.

These clauses also provide a competitive atmosphere for an increased number of small business firms. When prime contractors are encouraged to use more small and small disadvantaged firms they will begin to compile their own MBE listings of those businesses with good performance records. In addition, contractors will, as always, compare prices among small businesses capable of working on a particular job. As small businesses become more proficient in their performance, they will inevitably be given more and more subcontracting opportunities by prime contractors.

It should be apparent from this brief discussion that P.L. 95-507 can be of significant assistance in dealing effectively with some of the problems facing both government and small businesses. All that is needed now, is a positive commitment by government and private industry to make it work.

RECOMMENDATIONS FOR IMPROVEMENT OF P.L. 95-507

While we think P.L. 95-507 sets a new and important direction for the reasons given above, nevertheless, there are aspects of the law which should be modified.

First, we believe that this Act can be significantly improved by reducing the threshold dollar amounts for subcontracting. There is a great deal of government contracting done in the service and supply area, for example, that is valued less than $500,000. This would provide more subcontracting opportunities for small business concerns.

Secondly, the small and small disadvantaged business exemption under Section 211(7) should be eliminated. This section does not require a prime contractor who is a small or small disadvantaged business to comply with the subcontracting requirements of section 211. The legislative history indicates that Congress' rationale for such a exemption was based on the fact that Congress did not want to burden small businesses

with that much additional paperwork. Whether this concern is legitimate cannot be determined by the authors, but it appears that a lot of subcontracting dollars are being kept from small business concerns based on this rationale. We do realize that small businesses may not normally be in a position to give technical assistance to other small business concerns. However, when a small business believes it is competent enough to accept a Government contract that has subcontracting opportunities, and is found responsible by the Government, it should be capable of providing adequate technical assistance to its subcontractors.

The most important change that should be made to P.L. 95-507 centers around the way subcontracting plans are developed under the Act. In April 1978, before the passage of P.L. 95-507, OFPP published for comment in the Federal Register a proposed minority subcontracting plan, to be promulgated administratively. The plan would have applied to most federal contracts expected to exceed $500,000.

In negotiated contracts, all offerors would have been required under the OFPP proposal to submit a summary plan for subcontracting to minority businesses. This summary plan would be used as an important evaluation factor in selecting the contractor. A more detailed plan would then be negotiated with the apparent successful offeror and would be incorporated into the resulting contract.

In formally advertised contracts the OFPP subcontracting plan required the negotiation of a detailed plan with only the low bidder. Neither of these concepts were included in P.L. 95-507. Instead of a summary plan submitted by all offerors in negotiated procurement, P.L. 95-507 requires that a final plan be negotiated with the successful offeror. Thus, the element of competitiveness, which would frequently enhance the final plan, was eliminated. However, even the concept of "negotiating" the plan with the successful offeror was preferable to merely requiring the successful bidder to submit a plan, without negotiation. But in advertised procurement, P.L. 95-507 does not even require a "negotiated" plan for the low bidder; it requires only that the low bidder submit a plan. In both of these instances, the Act differs materially from the OFPP proposal.

We believe that the above changes would significantly improve the effectiveness of the Act.

THE ROLE OF PRIVATE INDUSTRY

In addition to government contracts, there is a massive opportunity for small business assistance in commercial contracts. We would like to now briefly discuss a situation where a private corporation voluntarily developed a program designed to provide technical and management assistance to small and small disadvantaged business concerns.

Control Data Corporation, a major computer company headquartered in Minneapolis, Minnesota, recognized that the true innovators in any business are small technically oriented entrepreneurs who have more creativity than money. But it takes money to provide the facilities necessary for testing and refining an idea into a product that can be successfully marketed in today's business environment. For those reasons the Control Data Corporation decided to establish "Business and Technology Centers" designed to give small business, at a fraction of the cost, many of the same resources available to larger corporations. Some of the resources provided by the Centers include technical knowledge in the areas of accounts receivable, sales analysis, general ledger accounting and job costing. The Centers also developed "Satellite Laboratories" whereby a small and small disadvantaged businessman may gain expertise in fields such as product safety and failure analysis.

Technical, managerial, and financial assistance to small business can also be provided to small businesses through "community cooperation offices", another concept developed by Control Data. One such office is the Minnesota Cooperation Office (MCO) located in Edina, Minnesota. The MCO was formed in 1979 to strengthen private sector job creation in Minnesota by creating and fostering the growth of new, technology oriented businesses. This is accomplished through the use of four "resource banks" entitled Business Opportunities, Entrepreneurs, Volunteer Consultants and Capital Sources.

The Business Opportunities Bank houses a catalogue of product ideas which come to the MCO from inventors, computerized data banks of technology and the MCO "Technology Transfer Programs." The Technology Transfer Program is to commercialize (1) university discoveries that have not been exposed effectively to the business community, and (2) corporate research that remains undeveloped because it does not "fit" that companies strategy.

The Entrepreneurs Bank compiles the names of individuals who have the background and desire to manage a business but lack an appropriate idea around which to build a company. These entrepreneurs come to the MCO to shop the Business Opportunity Bank.

The Volunteer Consultants Bank is for a person starting a business and is skilled in certain areas, but needs assistance in others. The MCO is assembling a pool of volunteers with expertise in each business discipline to advise MCO clients.

And finally, the Capital Sources Bank provides information about numerous forms of financing, including state and federal government programs. These types of programs are clear examples of the types of things that large businesses can do to assist in the growth and development of small and disadvantaged businesses. However, this is not

to imply that Control Data Corporation is the only large firm that has developed this type of program. Perhaps half of the Fortune 500 firms have special programs directed toward providing technical assistance and increasing their purchases from small and disadvantaged businesses. The Minority Purchasing Council estimates that such spending by private firms exceeds $2.6 billion in 1979, up from a mere $87 million in 1972. Given the obvious benefits from such programs and the impetus of federal programs requiring procurements from small and small disadvantaged businesses, the upward trend appears certain to continue.

CONCLUSION

Hopefully this paper has dispelled some of the myths that have been developed as a result of a misunderstanding of what P.L. 95-507 was enacted to do. It's more than just a means designed to funnel government dollars to small and small disadvantaged business entreprenuers. This Act services a more acute problem of small businesses, that of providing the technical and management know-how that will equip these businesses to become viable independent enterprises, enterprises capable of ultimately competing in the open market for not only a fair share of government contracts, but also a share of business generated in the private sector.

With a positive commitment of government and the innovative efforts of many private sector businesses, such as Control Data Corporation, we can attain the goals envisioned by Congress which resulted in the passage of P.L. 95-507.

EFFECTIVE ACQUISITION THROUGH THE ELIMINATION OF WASTEFUL YEAR-END SPENDING -- HEW, A CASE STUDY

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ABSTRACT

The purpose of this paper is to present the findings of research conducted on the quantity, causes and impacts of wasteful year-end spending in the largest federal agency -- DHEW, and to recommend strategies to preclude the annual recurrence of this negative influence on effective management of acquisition. The paper will offer both the graphic presentation and the detailed analysis of the research results as well as a model of advance procurement planning paralleling budget priorities in anticipation of various funding levels. The model will demonstrate procurement planning as a logical outgrowth of a proper budget formulation process.

The views set forth in this paper are those of the authors and should not be construed to represent the official position of any Government agency unless so stated.

Traditionally, most executive departments and agencies with annual appropriations obligate the bulk of their procurement dollars near the fiscal year-end and are thereby compelled to engage to varying degrees in wasteful and unnecessary contracting to avoid returning spendable funds to the Treasury.

The effects of this compression of the procurement process into the final stages of the Fiscal Year has been noticed at high Government levels and each administration in recent years has sought improved performance. Memoranda from the White House, pronouncements from Congress and the now yearly exhortation by the Director of the Office of Management and Budget all seek to have departments avoid a high ratio of year-end buying. Yet in spite of this widespread attention from both the legislative and executive branches, the response has been less than gratifying in most departments and heavy year-end spending and concomitant waste persists unabated. (See Table 1 entitled "The Year-End Spending Spree" printed in the March 7, 1980 issue of the Washington Post which summarizes data provided to Representative Herbert E. Harris by the General Accounting Office.)

Table 1

THE YEAR-END SPENDING SPREE

For Year 1979 (Millions of Dollars)

Agency	Total Obligations	Aug/Sept Obligations	Percent
HUD	$34,072	$16,107	47.2%
EPA	$ 5,356	$ 2,238	41.7%
HEW	$62,687	$14,360	22.9%
Commerce	$ 2,991	$ 907	30.3%
Interior	$ 6,026	$ 1,395	23.1%
Postal Service	$14,774	$ 3,273	22.1%
DOT	$ 6,201	$ 1,420	22.8%

This paper is a case study which relates facts and experience gathered while conducting research into the content and characteristics of year-end spending in HEW during FY 79.

The purpose of the paper is: (1) to briefly describe the extent of the year-end spending dilemma at HEW; (2) to consider significant causes and effects of this continuing problem and (3) to describe recent HEW initiatives to remedy the problem which may be generalized for use by other agencies to prevent the annual recurrence of this universally negative influence on the effective management of acquisition.

Extent of Year-End Spending

Our review included the compilation, verification and analysis of all available FY 1979 contract award data for each procuring activity in the Department. It also included detailed on-site reviews of four major contracting offices, which were selected because of their anticipated poor fourth quarter performance and their accessibility.

The major finding which emerged as a result of this effort was that year-end spending in the

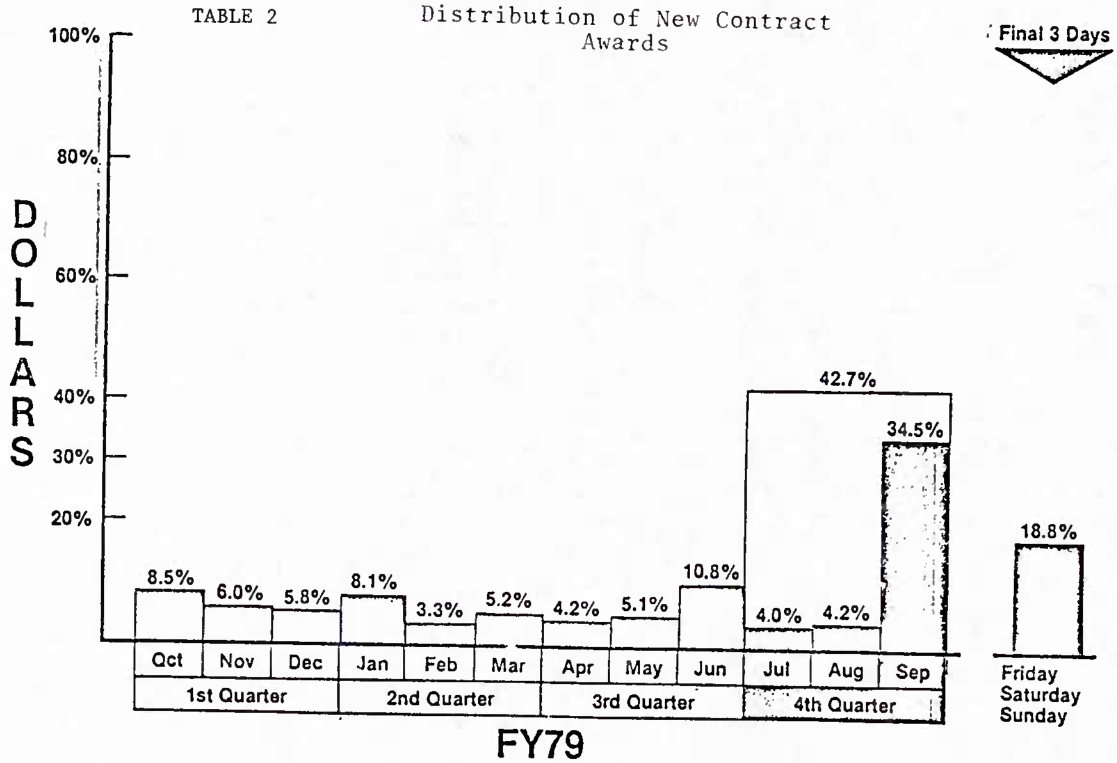
Department was significant and in some cases, overwhelming. Tables 2 through 5 depict the new contract dollars awarded in each month as a percentage of the total new contract dollars awarded by various Principal Operating Components of HEW in Fiscal Year 1979. Every component awarded more in new contract dollars on Friday, Saturday, and Sunday, September 28, 29 and 30, than in any other month of the fiscal year.

In one case a component awarded 97% of its annual contract dollars in the fourth quarter and 74% on the last three days.

HEW

TABLE 2

Distribution of New Contract Awards



COMPONENT A

TABLE 3

Distribution of New Contract Awards

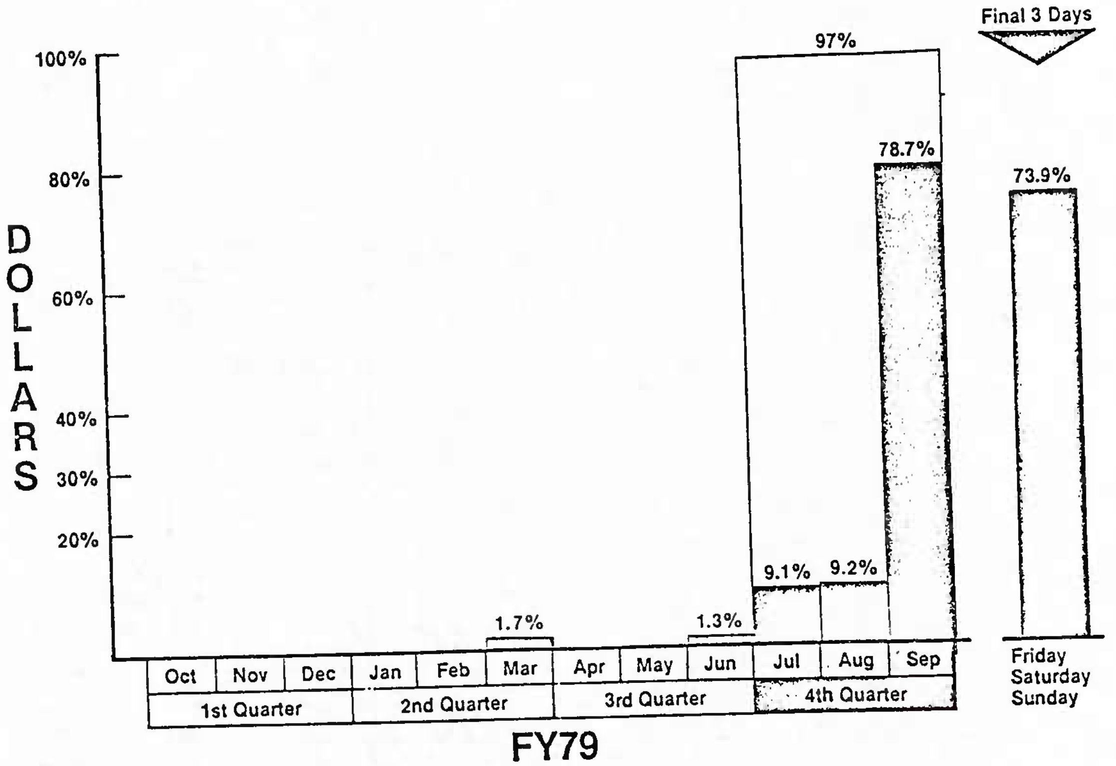


TABLE 4

COMPONENT B

Distribution of New Contract Awards

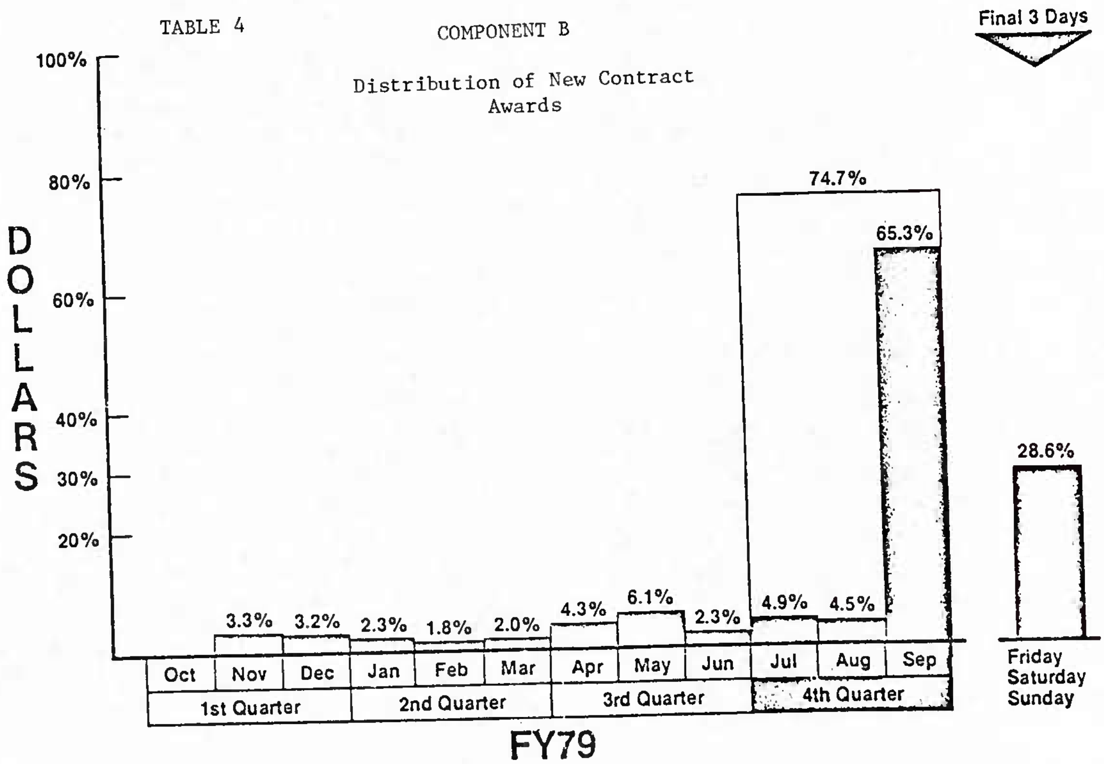
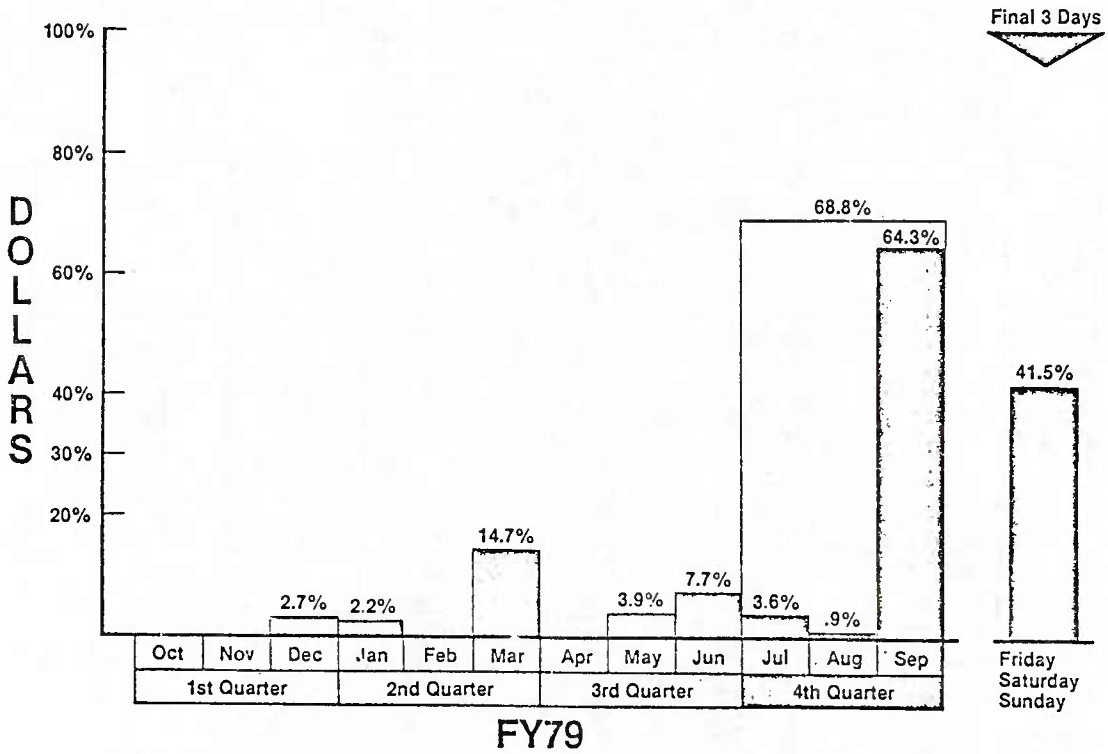


TABLE 5

COMPONENT C

Distribution of New Contract Awards



Effects

Our detailed on-site studies isolated several adverse effects of intense year-end spending which occurred consistently throughout the sample:

- Inaccurate or incomplete descriptions of the Government's requirements resulting in poor proposals, unrealistic prices and poor contracts.
- The uncritical acceptance of costs as proposed without the meaningful analysis of the components of those costs and without meaningful negotiations. A large percentage of the files reviewed lacked the required documentation necessary to determine the fairness, reasonableness and necessity of the awards.
- Poor utilization of resources for much of the fiscal year.
- Inadequate time for competition resulting in increased pressure to approve unjustifiable sole source awards.
- The inability of contractors to submit proposals because their resources are strained by the deluge of Request for Proposals available at the same time.
- Questionalbe awards to avoid loss of funds; for example:

  -"Banking" -- Allows agencies to record expiring funds as obligated without having reached complete agreement on the terms, conditions, or work to be performed by the contractor. This can be done by interagency transfer, by adding funds to an existing contract or by awarding a contract to the Small Business Administration. The latter involves eventually negotiating with a minority firm sometime in the next fiscal year.

  -Use of FY 79 Funds for FY 80 Work. A significant portion of HEW's contracts were awarded with start dates of Sunday, September 30 and thereafter. While the "needs theory" in contract law permits the obligation of existing funds at the end of a fiscal year for nonseverable requirements which existed

in the year for which the appropriations were available, it violates the intent of the Appropriations Act to use FY 79 funds for FY 80 work. The review clearly revealed that this practice is extensive.

-Misuse of Modifications. Significant year-end spending was also accomplished by modifications to existing contracts. The process of awarding modifications generally consumes less time than that of letting new contracts because source selection is not repeated and only the changed aspects are negotiated while the contract's other terms and conditions generally remain the same. When employed properly, modifications are useful instruments which accommodate necessary changes to the original contract. However, because of the modification's expediency, it has been used to avoid loss of annual funds at the expense of prudent spending of the Department's dollars. Examples include:

- o Contracts modified to provide funds in anticipation of future task orders (to be determined in FY 80).
- o Modifications awarded to improperly renew expired contracts in order to obligate dollars at the end of the year.
- o Multi-year projects modified at year-end to obligate funds far in excess of planned incremental needs.

Causes

Why is there this massive onslaught of requirements at the end of the fiscal year? The basic recurring problem at HEW is that agency heads and senior program managers are not adequately managing the process by which program requirements are identified, defined and translated into specific procurement packages early enough to allow an even distribution of contract solicitations and awards throughout the fiscal year.

Requirements packages were submitted to the contracts offices reviewed late in the fiscal year, often past the deadlines established by agency policy. Program officers interviewed stated that they could not begin developing requirements packages until funds had been allotted and allowances received, which often delayed submission of these procurement requests by several months.

To aggrevate matters, the increasing regulatory and clearance requirements imposed at different stages in the procurement process often causes the overall length of the process to span six months or more, thereby assuring that already late requirements will be awarded at the end of the fiscal year.

These considerations led us to inescapable conclusions concerning strategies to confront the year-end spending problem:

I. Between the expansion of the already lengthy procurement process, the pressure to spend appropriated funds and the apparent unwillingness of the Congress (with a few exceptions) to allow the carry-over of appropriations, there only remains earlier procurement planning and scheduling as an alternative to heavy year-end spending. This planning should be a logical outgrowth of a proper budget formulation process.

II. The current budget development process generally appears to be independent of actual requirements and the spending process. Program offices must establish procurement plans paralleling their budget priorities in anticipation of various funding levels rather than waiting for funds allotments.

HEW's Phased Approach to the Year-end Spending Problem

To accomplish the goal of improving the management and scheduling of contract awards to avoid the historic pattern of wasteful and unnecessary year-end spending, a three phase plan was designed to immediately control the spending at fiscal year-end, to apportion spending throughout the contracting cycle, and by FY 82, to align advance procurement planning with the budget formulation process.

Phase I FY 80

Phase I contains interim measures designed to effect immediate control over fourth quarter spending in FY 80 by instituting budgetary controls through the agencies' actual allotments and allowances to restrict the dollars awarded for contractual actions in the fourth quarter to not more than 30% of the cumulative annual procurement total for FY 80 (with not more than 12% in any month of the fourth quarter). Agency heads have the administrative flexibility to adjust the application of these limitations on obligations in order to accommodate the realities of essential mission needs within their component organizations. However, a minor relaxation of the limits in one program area must be balanced by a corresponding reduction in another program(s) to remain within the quarterly and monthly percentage ceilings on overall agency obligations. This is coupled with the application of an obligation control point mechanism, which prior to award of every contractual instrument validates that funds are available within the established limitations. These controls were combined with the requirement for agencies to establish and implement systems to incentivize the early submission of administratively complete and sound procurement packages.

Hence the objective of Phase I was active involvement by the Department's top management to effect improvements by imposing controls and demonstrating the will to enforce the new system even at the potential expense of lapsed funds. In February, 1980 the Secretary delivered a speech to the annual gathering of HEW's Senior Contracting Officials and the Under Secretary issued a memorandum reiterating that the agency heads would be held personally accountable for effectively implementing these controls.

Phase II FY 81

In contrast to the interim constraints and controls of FY 80, Phase II is designed to place emphasis on early identification and definition of an agency's contract needs as a means of achieving a reasonable distribution of solicitations and awards over the fiscal year. Instead of financial controls, the Secretary will rely on a Departmentwide monitoring and accountability system to manage the annual procurement program planning in FY 81.

Accountability under Phase II again lies with agency heads who are required to submit to the Secretary overall agency schedules which plot the planned distribution of contract awards over an eighteen month timeline extending to fiscal year-end.

These schedules are updated quarterly to compare planned versus actual progress and, when necessary to revise the schedule for the remainder of the fiscal year.

Each agency head retains the flexibility to establish a feasible agency schedule, recognizing that his or her performance will be measured by both the degree of the schedule's attempt to spread the contract workload and the effectiveness of the agency in actually meeting the schedule.

Tables 6 and 7 illustrate the basic design of the required schedule and update system which tracks planned versus actual accomplishment of two events - delivery of the procurement request to the contracts office ("R") and date of award ("A").

TABLE 6
Initial Planning Schedule

Agency ______
Agency Head ______
Phone # ______

Project Office Decision Package or Project Program Manager, Phone #	(000) Budget		FY 80						FY 81													Annual Totals
			Qtr 3			Qtr 4			Qtr 1			Qtr 2			Qtr 3			Qtr 4				
	Total 50,000	Prior	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Project Office A Manager Name, Phone Project or Decision Package #1	10,000						R		R			A		RA						A	
Project or Decision Package #2	4,000					R							A		A					A	
Project Office B Manager Name, Phone	7,000				R							R				A		A			
Project Office C Manager Name, Phone Project or Decision Package #1	8,000	R							A		R		R			A		A			
Project or Decision Package #2	6,000		R	R					R	A			A				A				
Other Project #1	7,000	R		R	R				R		A		RA			A		A		A	
Project #2	8,000		R	R			R			R		A	A	R	A				A	A	
Monthly Totals (000)																					
RFC Total Dollars	Planned	3,000	3,000	5,000	3,000	5,000	7,000		8,000	1,000	3,000	4,000	4,000	4,000							
	Actual																				$50,000
Award Total Dollars	Planned								2,000	2,000	1,000	5,000	6,000	4,000	4,000	5,000	6,000	4,000	5,000	6,000	$50,000
	Actual																				
Actual Awards	Monthly%																				

TABLE 7

First Quarterly Update

Agency ____________
Agency Head ____________
Phone # ____________

Project Office Decision Package or Project Program Manager, Phone #	(000) Budget		FY 80						FY 81												Annual Totals
			Qtr 3			Qtr 4			Qtr 1			Qtr 2			Qtr 3			Qtr 4			
	Total 50,000	Prior	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Project Office A Manager Name, Phone Project or Decision Package #1	10,00						R		R			A		A	R					A	
Project or Decision Package #2	4,000					R							A		A					A	
Project Office B Manager Name, Phone	7,000				R **R**							R					A		A		
Project Office C Manager Name, Phone Project or Decision Package #1	8,000	R **R**							A		R		R			A		A			
Project or Decision Package #2	6,000		R	R		R		R	R		A				A		A				
Other Project #1	7,000	**R** R		R	**R**	R			R		A		R A			A		A		A	
Project #2	8,000		R	R		R	R R			R		A	A	R	A				A	A	
		Comparison of Planned vs. Actual				Rescheduling of RFC and Award Milestones over the Remainder of the Planning Cycle															
Monthly Totals (000)																					
RFC Total Dollars	Planned	3,000	3,000	5,000	3,000	8,000	9,000	1,000	8,000	1,000	3,000	4,000	4,000	1,000	3,000			RFCS Remaining			$42,000
	Actual	3,000			5,000																$8,000
Award Total Dollars	Planned								2,000		3,000	5,000	6,000	3,000	5,000	5,000	6,000	4,000	5,000	6,000	$50,000
	Actual																				
Actual Awards	Monthly%																				

The scheduling is done at both the individual program office and agency levels. While the program office schedules virtually all contract requirements and resulting awards, the agencies schedule them in summary terms by simply consolidating and refining program inputs. Hence "R" and "A" symbols appearing on agency schedules are likely to represent groups of requirements and awards.

Responsibility

Phase II represents a major departure from previous attempts to control year-end spending in that it places the accountability for management and long range planning of program requirements with agency heads and project officers who are involved in the front end of the acquisition process rather than with contracts personnel who have little control over the timing of project identification and definition. It is the project officers who provide the input for the schedules and initiate their execution by planning projects sufficiently early to allow an even distribution of awards over the fiscal year.

The Role of the Contracting Officer in Phase II

The interface with the contracts office occurs later in the process when project officers coordinate individual requirements with contracting officers to be analyzed and structured in contractual terms and ultimately incorporated into solicitations. At this point the role of contracts officials is to assure that proposed requirements are administratively sound; i.e., they must contain the required clearances, foster competition to the maximum possible extent and clearly express the Government's needs and acceptance criteria.

Also during the early stages of coordination between project and contract officials, planned award dates for individual contracts are jointly established thereby determining the distance between "Rs" and "As" on the program office schedules.

This is a key responsibility because scheduling adequate time for proper solicitation, evaluation, negotiation and award procedures (in order to obtain benefits in terms of cost and quality of products and services acquired) is the central purpose of annual procurement planning.

Thus Phase II is designed to stimulate early planning of requirements and to afford agency heads and the Secretary the ability to track the Department's progress in controlling year-end spending. It allows the Secretary to evaluate the adequacy of initial schedules and agency performance in meeting them to determine whether a re-imposition of financial controls will be required.

Phase III FY 82

As stated earlier, late appropriation of funds by Congress has frequently been cited as a major impediment to annual procurement planning. Program officials complain that development of procurement requirements is delayed until funds have actually been alloted late in the acquisition cycle.

Although this obstacle cannot be entirely eliminated, its effects on acquisition planning can be greatly minimized by linking the annual procurement planning process to the budget formulation process.

The major objective of Phase III is to accomplish this linkage to the greatest practical extent. It calls for program officials to develop procurement requirements based upon anticipated funds allotments, rather than waiting until funds are actually appropriated. Since developing these funding estimates is already a function of the budget preparation process, Phase III attempts to align the two processes of budget and acquisition planning.

HEW's Zero Base Budgeting (ZBB) system should facilitate identification and at least rudimentary definition of those procurement projects with high probability of being funded because ZBB requires analysis of programs, development of discrete decision packages and the ranking or prioritizing of these packages.

Hence for FY 82 in addition to continuing the scheduling system implemented in the previous year, HEW agencies are asked to initiate annual procurement planning simultaneously with the budget formulation process. A new set of planning milestones are established to coincide with early budgeting events as depicted in Table 8 below:

TABLE 8

LINKAGE OF EARLY MILESTONES FOR BUDGETING AND ADVANCE PROCUREMENT PLANNING

BUDGET PROCESS		ANNUAL PROCUREMENT PLANNING PROCESS
April 80	- Office of the Secretary of HEW issues internal instructions to agencies on preparation of annual budget estimates	- A section of these instructions requires an additional core submission which identifies contract and grant dollars.
June 80	- Agencies submit data items, ZBB ranking tables, facilities requirements and other variable submissions associated with the budget in accordance with the internal instructions.	- Agencies submit as part of the core submission a table which roughly summarizes by program activity the number and dollar value of planned FY 82 acquisition and assistance packages. (At this point it may not be possible to distinguish potential grants from contracts)
Sept 80	- HEW submits formal estimates for the annual budget including projections for requirements of future years and supporting materials to the Office of Management and Budget (OMB).	- In the process of establishing the formal ZBB estimates for OMB, the acquisition and assistance summary table is refined for each agency and resubmitted to the Office of the Secretary. (At this point program officials can identify major contractual efforts and begin planning requirements).
Jan 81	- HEW's formal budget is published for the President.	- The acquisition and assistance summary is again updated and submitted to the office of the Secretary. Program officials begin to develop concrete procurements based upon anticipated funding levels and coordinate them with contract officials. (In April 81 agencies submit their initial annual procurement planning schedules as they did for Phase II).

Hence Phase III represents the culmination of HEW's current efforts to control year-end spending by effecting earlier procurement planning as a logical outgrowth of the budget formulation process.

If the system is implemented effectively, it offers great potential for savings by scheduling adequate time in the acquisition process to accurately define Government requirements, obtain true competition, prepare thoroughly for negotiations and issue clear and enforceable contract terms. It will also alleviate the tendency to wastefully dump funds at fiscal year-end on hastily planned and unnecessary projects.

Potential for Success

The potential for success of this system in HEW or any like it in other Government organizations hinges upon several important factors.

- The continued commitment of HEW's top managers;

- The ability of the Secretary's advisors to monitor the progress of the Department in controlling year-end spending. (The Department's Contract Information System will be harnessed for this purpose);

- The ability to train and motivate the personnel responsible for implementing this system;

  - Project officers training courses will be revised to include discussion of the 3 phased approach outlined in this paper; and finally,

- The ability of the Department's leaders to maintain a clear conception of the true objectives of this initiative so that the coordination and control mechanisms do not become ends in themselves. The Secretary and her managers of the system must retain the flexibility to consider problems or unforeseen conditions that warrant changes.

PRODUCTIVITY

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PRODUCTIVITY IMPROVEMENT THROUGH INCENTIVE MANAGEMENT

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ABSTRACT

As the rate of productivity has declined in the United States during a period of rapidly escalating labor costs, interest has grown among Department of Defense, other Governmental, and private sector workforce managers to utilize effective and cost efficient techniques that enhance productivity outcomes. Presidential concern has been aroused and the 1978 Civil Service Reform Act mandates increased efforts toward stimulating productivity growth. A systematic analysis of 54 cases in which incentive management strategies were tested and the consequences measured found that these workforce motivators were responsible for yielding an average increase in worker productivity of 23.1 percent and in performance quality of 11.0 percent. Overall, the research concludes that different incentive strategies should be designed to meet the contingencies of particular work situations. In some contexts, cash bonuses are the most effective, while in other work situations, recognition and the granting of special privileges have a greater impact on motivating peak performance.

THE PROBLEM

At a time when the Department of Defense and other Governmental agencies face tight budgets, reduced availability of manpower and resources, persistent inflation, and public demands for greater efficiency in the delivery of services, increased productivity efforts are required in the public sector. The establishment of the National Productivity Council in 1978 and the Defense Productivity Program Office, OASD (MRA&L) symbolizes a new national impetus to overcome obstacles that have reduced productivity growth rates in the United States over the last two decades.

Management Objectives. Management's efforts to improve worker productivity are often focused on optimizing four interrelated goals:

1. Increasing quantity (more production).
2. Improving quality (fewer errors and rejects).
3. Cost reduction (more efficient use of time and cost-benefit ratios).
4. Improving the quality of worklife (increasing job satisfaction and thereby reducing turnover, absenteeism, and grievances, and stimulating better worker ideas).

Productivity Improvement Techniques. There are several basic methods that can be used to stimulate productivity improvement in these four goal areas. While the private sector has pioneered each of them, many variants have been applied in the public sector. They include:

1. Capital investment. In the private sector, improved technology and new capital goods can contribute up to 60 percent of productivity increases (1).
2. Work measurement and standards. The establishment of performance standards for particular functional areas can yield increases in productivity up to 80-85 percent (2).
3. Quality of worklife improvements. Research has indicated that redesigning jobs, improving work conditions, and creating the opportunity for worker participation can enhance productivity outcomes significantly.
4. Motivational incentive tools. Effective utilization of workforce resources through rewards for performance can improve productivity substantially (2, 3). Financial as well as nonfinancial incentives are now encouraged in the public sector as a result of the Civil Service Reform Act of 1978.

The current research focuses on the fourth improvement strategy. Incentives can be defined as inducements that attempt to direct the performance of an employee or supervisor toward management-desired goals. The motivational management tools can take the form of monetary bonuses for above standard performance, nonmonetary supervisory recognition of outstanding work, or time off with pay as a reward for superior productivity, for instance. A recent study (4) found evidence of 27 ongoing incentive pay programs alone in various activities in DoD.

Only these positive extrinsic incentives are examined in this study since they are easier to identify, observe, implement, measure, and control than intrinsic work reward programs, such as job enrichment, participant goal setting, and feedback techniques. Extrinsic incentives are often successful motivators if they are granted contingent upon superior performance, valued by the workers, and tailored to the needs of the personnel, job function, and organization.

The present effort attempts to provide a sytematic framework of the available empirical research on the productivity impacts of incentives under a wide variety of work conditions. The basic question that underlies this study is to identify the workplace factors under which extrinsic incentives are likely to succeed in improving worker productivity and when they are likely to fail.

WHEN INCENTIVES SUCCEED

A preliminary database was developed containing 54 cases in which the impact of extrinsic incentives was evaluated quantitatively in industrial, governmental, military, educational, and laboratory settings (5). Over all 54 cases, incentive management techniques elicited gains in productivity of 23.1 percent and in performance quality of 11.0 percent. The specific circumstances under which these techniques were successful follow:

- Blue collar workers are motivated to significantly higher performance levels by recognition or privileges (up 87%) and disciplinary actions (up 46%), not by cash.

- When tasks are inherently interesting, variable cash bonuses yield significantly more effective qualitative results (up 48%). With boring tasks, however, workers are stimulated by cash-noncash mixes (up 35%) and by recognition or privileges (up 87%).

- In training tasks, variable cash bonuses are most effective in assuring high quality performance (up 48%).

- When immediate feedback on a worker's performance is provided, noncash recognition or special privileges are the most effective motivators (productivity up 87%). However, when performance feedback is delayed, variable cash bonuses yield significant quality (up 48%) and quantity (up 40%) gains, while cash and noncash incentives mixes yield high productivity improvements (up 31%).

These results confirm the utility of incentive management techniques in a wide range of workplace situations, but suggest that incentive strategies must be tailored to the specific work context to optimize productivity outcomes. Interestingly, noncash incentives appear to be highly successful and low cost motivational tools.

Morever, a category of incentive tools -- that has been inadequately researched in the past -- variable cash bonuses -- appears to have significant impacts on productivity and quality. These incentives are presented on an uncertain schedule. This means that workers are not rewarded for every instance of superior performance. Therefore, they are motivated to perform at high levels all of the time since reinforcement is upredictable.

THE INCENTIVE MANAGEMENT DECISION PROCESS

A decision network of the process by which management decides to employ incentive techniques to stimulate productivity and then tailor a strategy to the needs of the organization, management, and employees has been designed (6). This sequential process includes the following decision points:

- What types of incentives plans can be considered?

- Are there any legal, regulatory, or policy restrictions that would preclude use of the incentive plan considered?

- What costs will be involved in carrying out the incentive plan being considered? Does the agency have the funds to implement it?

- Is the value of the expected productivity increase sufficient to warrant the costs involved?

- What are the characteristics of the workforce?

- What is the current work environment?

- Are the employees members of a labor union? If so, will there be any problems in securing concurrence from the union for implementation of the plan?

- What are the likely reactions of the employees to the plan?

- Does the installation or activity have adequate administrative capabilities to support operation of the plan?

- Are there existing standards for work output in the functions involved?

Essentially, these questions describe the outline for an organizational diagnosis that must be conducted to identify the need for a design of tailored incentive strategies than can optimize productivity.

INCENTIVE MANAGEMENT AID

A computer-based decision aid (6) has been designed to provide:

- Integrated and quantitative information on previously evaluated incentive plans.

- Recommendations on effective incentive plans matched to organizational contingencies.

- A method by which users can design innovative incentive strategies that may not have been tested previously.

While only a partial demonstration package has been implemented to date, the final system -- if it is developed -- would enable managers and researchers to design optimal productivity solutions for their organizations.

The final design of the system includes several database modules that would contain quantitative data from field tests on basic descriptions of incentive plans, their organizational context, productivity outcomes, job satisfaction, and intrinsic incentive methods.

In addition, analytical modules would provide users with an efficient and meaningful way to arrange, display, and analyze productivity data for practical application. These modules would include an incentive MIS, productivity statistic displays, tailored incentive design components, intrinsic reward analyzers, and quality of worklife statistic displays.

CONCLUSIONS

The analytical findings confirm the contingent nature of successful incentive management. The effectiveness of any strategy is greatly affected by the work context in which it is used. Expanded incentive management research holds out the potential for higher productivity growth rates, lowered manpower costs, increased performance quality, and enhanced quality of worklife.

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WORK SIMPLIFICATION TECHNOLOGY AS AN ACQUISITION PARAMETER

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ABSTRACT

The media is full today with analysis on the lack of productivity. Productivity is, in one perspective, the elimination of waste. Waste motion analysis is not new --- but the partial automation of the analysis is a positive technical advance. The computer combined with video tape recordings (VTR) has the potential, however, for changing this method of study.

This paper presents the progress to date made on making methods' studies where the computer coupled to the VTR provide a modern day analysis tool. Software and hardware already beyond the bread-board stage and presently being refined provides a VTR to computer interface. This interface "Black box" allows the computer to reduce the data quickly to useable form. Analysis of this form provides the elimination of waste possibilities which impact on productivity.

THE PROBLEM

General. For only the third time since 1945 the annual productivity rate has declined.[1] In the years 1947, 1974, and 1979 this nation has experienced a negative rate of worker output. Though the figures for 1979 are small, 0.9 percent,[1] and the base from which we are operating, relative to our international competition, is large, the potential problems are great.

The extent of this potential is, perhaps, measured by the organizational effort and funding dedicated to it. The media, for example, is almost strident about productivity and the need for improvement in this highly undefined area. The spectrum of the printed word ranges from the Sunday supplement to the highly technical journal in many of the scientific professions. Much of the material is abstract or philosophical covering economic policy or conceptual perspectives of productivity. Much of the remainder is "war-story" or cookbook oriented on narrow or parochial views.

There is also a Federal Government thrust to this effort. The Office of Personnel Management (OPM) (the renamed Civil Service Commission) has established a Workforce Effectiveness and Development Group (WED), the Office of Productivity Programs (OPP), the Productivity Resource Center (PRC), and the Office of Intergovernmental Personnel Programs (OIPP). These combined with other already established government agencies such as the Bureau of Labor Statistics comprise formidable forces to encourage improved productivity.

In one sense, however, encouragement of improved productivity is the limit of organized or government effort. The accountable product (or service) first line managers and their subordinates are the ones who will see to it that the nation's productivity improves.

The Management Control Function. How will these managers do it?? They will do it as a part of their normal spectrum of implementing management theory. The function of Control is where Productivity and its measurement lies in management theory as a basic principle. Control is defined as "measuring and adjusting what is being accomplished, i.e. evaluating the performance and, if necessary, applying correcting measures so that performance takes place according to plans."[2] There are four elements accepted as encompassing the process of accomplishing this function: Measuring performance, Comparing with a standard, Correction of deviation, and Feedback of the performance data under a corrected environment. The entire process of this control function then appears to be almost synonymous with Productivity.

Given the above rationale, who are the professionals focusing on this area and what are they doing to improve the elements of the process? The industrial engineer and industrial management school graduates are probably the trained professionals. This provides a very broad area where the operations researcher and the more esoteric individuals can operate along with the classical IE's. The classical or traditional industrial engineer is still measuring work and analyzing motions for 'working smarter'.

What are these professionals doing to improve the process elements? One area of continuing improvement is the stopwatch. Digital readout and other technical improvements are attempted to make easier the actual timing in the motion-time study effort.

Background. Another area of possible improvement in measuring is the focus of this paper.

Basic motion-time study equipment has not progressed much beyond the old stopwatch and clipboard coupled to the skill of the engineer-analyst. Laboratory work measurement tables using electronic timers and photo-electric cells have contributed to the equipment area but a flexible, easy to use piece of equipment useable anywhere for all kinds of motion and time studies has not been available.

Some years ago, while in the process of providing students with an easily learned means to repetitive analysis of their methods design in the Industrial Engineering Laboratory at Notre Dame, video tape recorders (VTR) were tried as a tool due to its use in several local areas. As the VTR became common among various industrial uses, i.e. security monitoring, training uses, etc. industrial engineers pyramided their knowledge and a technique of motion-time study developed. The technique is applicable to analyzing both group (or team) and individual work activities. Industrial companies presently using VTR's for motion-time analyses include Joy Manufacturing Co. of Michigan City, Indiana; Sibley Machine Foundry Corp. of South Bend, Indiana; Hobart Co. of Troy, Ohio and General Motors, Corp.[2,3,4,5]

However, the data analysis of the video tape is presently done manually for input to a computer for a time study analysis. A manual interface between any two pieces of equipment is, of course, a flag to any skilled I.E. It is a challenge to mechanize or automate the operation.

After gaining some skill in using VTRs in a motion analysis/time study mode,[6] the more innovative students began assembling their data in a computer format. This pressured the faculty to innovate on use of the two pieces of equipment, i.e. the VTR and the computer.

The video tape data with a digital time read-out, similar to Olympic competition scenes shown on commercial television, can be adapted and "read" into a computer to achieve an improved, i.e. reduced, man-machine interface. Hardware for this adaptation of VTR-to-computer is presently in the advanced or prototype stage.

A SOLUTION

Equipment Details. An interface box has been designed[7] and is in use for connecting the video tapes to the computer, an IBM-370-168. The video equipment is the Sanyo VC-500, battery operated camera and recorder for cassettes on half-inch tape.

The digital time interface box provides timing data on the video track of the tape during a recording session, and allows recovery of these timing data during both recording and subsequent playback functions. The retrieved data are shown visually by a 5-digit decimal display on the TV monitor and are transmitted as serial digital data in ASCII (American Standard Code for Information Interchange) code through a modem (modulator-demodulator) to a remote computer.

The timing data is stored on the video track rather than on one of the audio tracks of the tape. This permits data recovery during stop-action or slow-speed playback. The audio tracks are not operative when the tape is halted, of course, whereas, the revolving video recording head maintains uniform video output for varying tape speeds.

Figure 1. shows a block diagram of the interface box and its interconnections with the VTR (Video Tape Recorder), the local CRT (Cathode Ray Tube) terminal and the remote computer. During recording, the video camera is connected to Video Out on the interface box. The resolution of the timing information is determined by an external TTL-compatible pulse train connected to the Clock Signal input. These pulses increment a 5-digit binary-coded-decimal counter, having a counting range from 00000 to 99999. Thus, a clock period of 0.1 second would give a full scale count of 2.78 hours. The timing and control circuitry extracts vertical and horizontal synchronization signals from the Video Input to command loading of the current timing counter value into a 20-bit shift register at the beginning of each picture field. The 20 bits are shifted serially out of the register and combined with the video signal to produce the Video Output to the VTR. The timing information is not visible on the television screen because it is stored "off the screen" before the visible portion of each frame.

During playback, the output of the VTR is connected to the Video Input of the interface box. The timing and control circuits cause the recorded timing bits to be serially shifted into a register each time the operator activates the Data Request Switch. The bits are transmitted as five 4-bit binary-coded-decimal digits to a Light Emitting Diode display on the box and to a Universal Asynchronous Receiver Transmitter (UART). At the UART, four leading bits are added to convert each BCD digit into its corresponding 8-bit code in ASCII and the data are sent through Data Out to the Modem where it is relayed to the remote computer and to the local CRT terminal. The operator can communicate with the remote computer and control the action of the interface box solely from the CRT keyboard.

Equipment Use. In a typical application, the interface box would be attached during the recording of an employee's activity to provide timing information on the video track. The box would also be used during playback of the tape to send the timing information to the remote computer for data reduction and report generation. The industrial engineer controls the VTR playback in slow-speed or stop-action playback, as required, to evaluate the portrayed work activity. He is prompted at the CRT by the computer to enter a code number to denote motion elements being portrayed, and then enters a special character at the keyboard to indicate the beginning and end of the element. Upon receiving the special character, the interface box transmits the timing information from the tape to the computer, and the computer echoes it back to

the CRT for verification. The engineer may also enter appropriate codes at the keyboard to denote a performance rating or other information of the observed motion element. Figure 2 depicts the activity flow of these procedures.

After a taped activity has been analyzed and evaluated by the engineer he can, of course, direct the computer to prepare a summary report, file the data, make comparisons of the elemental times against Standards which may already be on file, or perform the many audits or other actions necessary to promote good motion and time study uses.

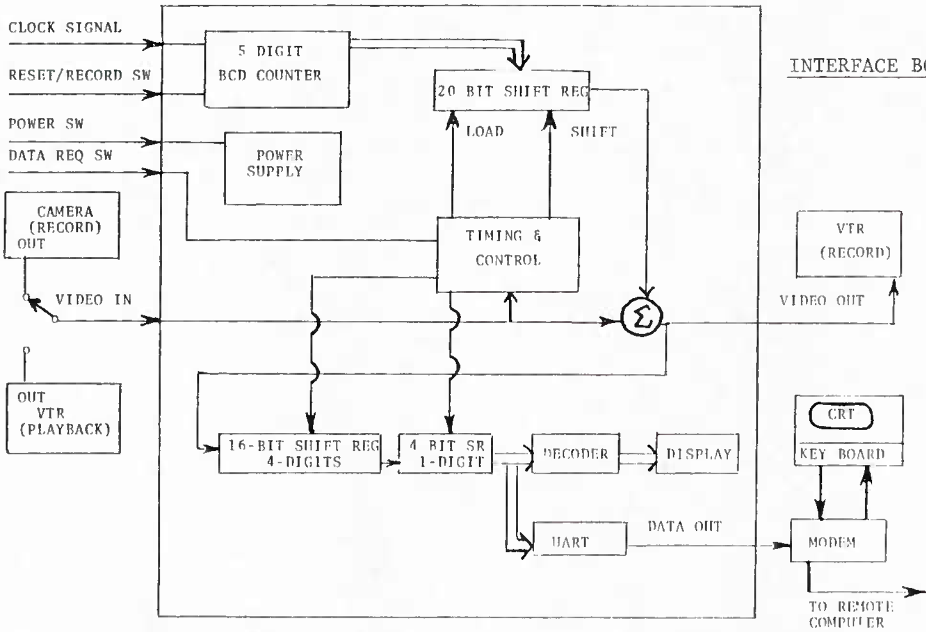

Figure 1. Block Diagram of the Interface Box and Connections

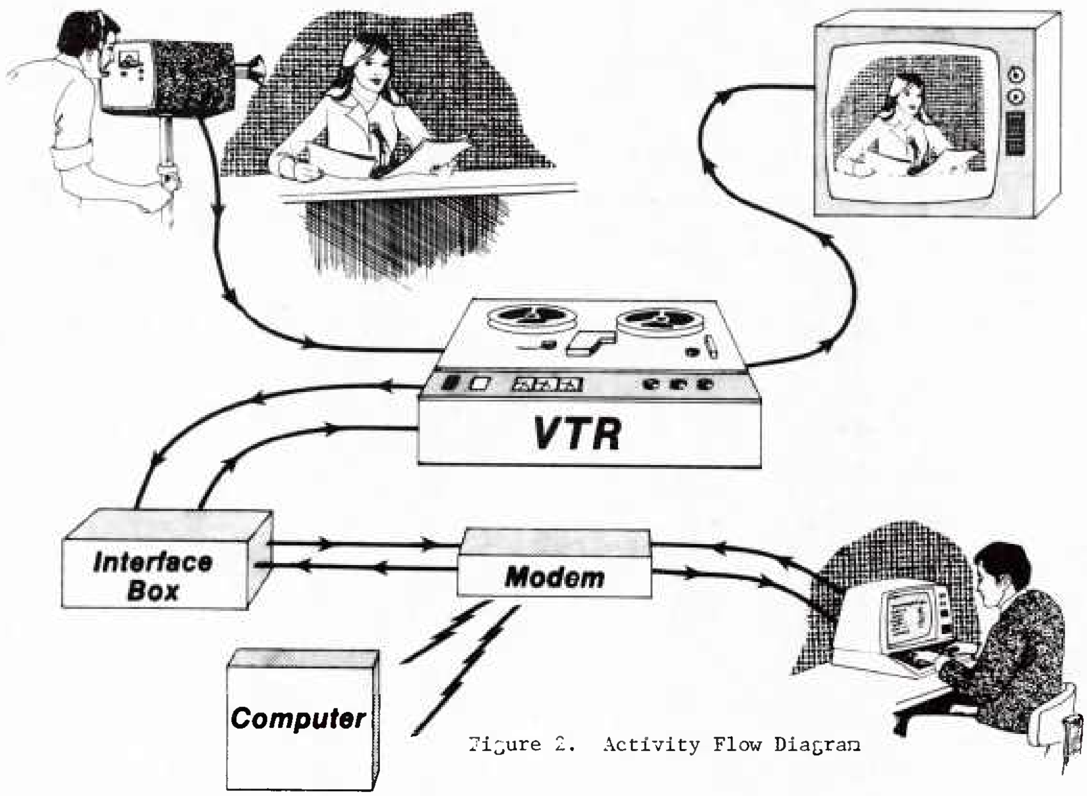

Figure 2. Activity Flow Diagram

Needed Equipment Enhancements. One of the immediate problems for wide application is, of course, the lack of the third dimension. This present liability forces the dimensional analysis for angular and linear displacements to be performed manually. With the advances being made in video equipment, in editing and other functions, however, two or three cameras set up in the proper fashion should give triangulation capabilities to the engineer for accurate distance profiles of the motion elements.

This triangulation procedure will probably give enough information for not only three-dimensional distance vectors but also the acceleration, deceleration and constant velocity factors so necessary to any complete study of the motions used.

Work Analysis. Given that a skilled industrial engineer can perform or obtain the proper motion-time study as has been performed for years, of what additional value will the more expensive method described above provide?

Industrial Engineering theory has for years used a basic scheme for simplifying work activities:[8]

1. Eliminate unnecessary activities.
2. Combine separate activities into continuous operations.
3. Change the sequence of activities.

These are each focused on simplifying work and can be applied to individual workers or teams of workers in manufacturing efforts as well as the white collar environment.

The application of this scheme coupled with the equipment use discussed earlier is probably best shown by illustrating the elimination aspect in an acquisition environment. Much of the easy improvements in productivity have taken place through the obvious improvements surfaced via even the most cursory analysis. The more difficult search for improvements will now require more intellectual effort. Since "good thinking" is not done on a highly structured and rigid schedule, the availability of video tapes for continuous and repetitive review at the discretion of the viewer is of great value. Ideas for eliminating activities, work elements, etc. will probably no longer be obvious but will take hard analysis.

Final inspection procedures, lot sizes and handling procedures, packaging materials and handling methods, and delivery techniques and traffic handling are examples of areas where this technique can be applied during the last steps of the vendor handling phase of acquisition. The capability to look repetitively at an activity in a quiet, study oriented environment, i.e. closed office, discretionary time, etc., is advantageous to more rigorous analyses where multiple alternatives can be explored via the computer interface and an optimum solution made available.

Two traditional industrial engineering phases summarize this area:

1. Time is the measure of productivity and
2. There's always a better way.

Each of these applies equally well to the improvement of productivity rates as perceived from the acquisition environment.

Summary/Conclusions. In this paper, the authors have brought together the concepts of productivity, the control function of management and the work measurement area of industrial engineering. The equipment in development to adapt video tape recordings to digital computers could be of significant value to the simplification of certain acquisition functions. The investigation of these functions with the focus on cost reduction is an area of potentially large savings and perhaps deserves your analysis as acquisition function managers.

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IMPROVING THE ACQUISITION SYSTEM

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ABSTRACT

The acquisition system has become inefficient and costly, particularly in the drain on time and talents of the limited supply of people capable of technological innovation. It is contended that "the system" was never designed, has no current master, and is, in effect, not subject to rational human control. To bring "the system" under control and to rationalize its operation, it is proposed to (1) make all managers in the acquisition system accountable for understanding, and taking effective actions to improve, that part of "the system" through which they discharge their day-to-day responsibility and (2) organizing the people who are "the system" into improvement teams to document and understand existing processes and devise and implement improvements. The collective result of such bottom-to-top, wall-to-wall improvement action will be to identify and exploit improvement opportunities at the lowest possible level and to free top officials to make those system-wide improvements which can only be accomplished on a total system basis.

This is not a conventional report on research, but rather a proposal for action to apply some of what we already know to bring the acquisition system under control and to rationalize its operation.

We contend that "the system" is out of control. It has become a monster that is threatening efficient accomplishment of the acquisition function in government. Under "the system", acquisition (1) takes too long, (2) costs too much, and worst of all (3) taxes away too much of the time and energies of the limited supply of people who are capable of contributing effectively to technological innovation.

This situation does not have to exist. We have the tools in hand, now, to bring the system under control and drastically improve the effectiveness and economy of government acquisition.

We do not have research-based statistical proof of the charges we have made. But, we know they are true because we have experienced "the system," each from a different perspective. Further, we are not alone in our concern with the cost and effectiveness of the acquisition process.

IS THE SYSTEM ALL THAT BAD?

In the late Sixties, the Blue Ribbon Defense Panel studied the acquisition process. Its Chairman, Gilbert Fitzhugh, characterized "the system" this way:

> Everybody is somewhat responsible for everything, and nobody is completely responsible for anything. So there's no way of assigning authority, responsibility and accountability. You can't hold anybody accountable. There is nobody that you can point your finger to if anything goes wrong, and there is nobody you can pin a medal on if it goes right, because everything is everybody's business, and as you know, what is everybody's business is nobody's business.
>
> They spend their time coordinating with each other and shuffling papers back and forth and that's what causes all the red tape and the big staffs in the Department. Nobody can do anything without checking with seven other people.(1)

David Packard, co-founder and Chairman of the Board of Hewlett-Packard Corporation, did battle with "the system" when he was Deputy Secretary of Defense in the late Sixties and early Seventies. In an address to the Armed Forces Management Association in 1970 Packard remarked:(2)

> I have been in this job now for 19 months. Frankly, I am ashamed I have not been able to do very many of the things that need to be done to improve the situation I found here in January 1969. The most frustrating thing is that we know how we ought to manage -- you, me, all of us -- and we refuse to change based on what we know. Every time we want something done in a hurry and want it done right, we have to take the project out of the system. We give a good man direction and authority and let him go -- and it works.
>
> . . . .
>
> On the other hand, when we are not in a hurry to get things done right, we over-organize, over-man, over-spend and under-accomplish. The most dramatic contrast is within Lockheed. Kelly Johnson and his programs, and the Air Force and Lockheed on the C-5A. I simply cannot understand why we are unable to change the system to avoid the C-5As and get more Skunk Works.

. . . .
In one case, a small dedicated Air Force team developed the gunships which have been so successful in Vietnam. The Air Force decided to put this program into its formal system. About a month ago I asked when we would be able to get some more gunships. The answer was in two years. That program is now out of the Air Force system, and we will have more gunships in six months.

The RAN/D&F Ritual

We have contended that "the system" is consuming our substance and is out of control. Let us illustrate using the case of the "ritual" of the RAN (Request for Authority to Negotiate) and D&F (Determination and Findings) for procurement of R&D.

The procurement laws and regulations prescribe "formal advertising" as the basic means of federal procurement. All procurement not accomplished by formal advertising is considered procurement by "negotiation," regardless of how much competition may be involved. Under formal advertising, sealed bids are submitted, publicly opened, and the contract awarded to the lowest bidder.

If procurement is to be by formal advertising, it is necessary to define in advance exactly what it is the government is trying to buy. Thus, there is no way that R&D can be procured through formal advertising.

Since R&D can't be procured through formal advertising, the law permits procurement of R&D through negotiation. However, the law requires that a D&F, authorizing waiver of the formal advertising rule, be issued for each R&D procurement.

For all procurements of over $100,000, the D&F must be signed at the secretarial level. Almost never is the Request for Authority to Negotiation, the "RAN," flatly turned down, but a lot of people have died or retired during the time required to push the RAN through the endless layers between the levels where the government's work gets done and the offices of the Secretaries

The cost of this ritual in manhours and degradation of effectiveness through delay of business is enormous but difficult to document in numbers. A senior official of the Blue Ribbon Defense Panel said the Panel identified an estimated 12,000 man-years a year in processing of RANs. If you consider 33 years as a typical federal career, then 12,000 man-years is the equivalent of 364 bureaucrat lifetimes sacrificed each year in this irrelevant ritual -- like throwing a bureaucrat into the volcano each day, except Christmas.

Looking at this ritual from the perspective of efficient acquisition, the Blue Ribbon Panel report of July 1970 observed that:(3)

> The consequence of the statutory prescriptions and the D&F requirements place the officers of the Department of Defense in the position of being required to document and explain why they are using the most appropriate procurement method rather than an inappropriate one. The preparation, review, submission and filing of the required D&Fs demand and receive a significant amount of personnel effort including that of the various Secretaries and Assistant Secretaries of each Military Department.

Recommendation II-23 of the Blue Ribbon Defense Panel reads:

> The Secretary of Defense should recommend to the Congress and to the existing commission on Government-wide procurement that the Armed Services Procurement Act and other applicble statutes be amended to reduce or eliminate the requirement for Determination and Findings on all negotiated contracts, to reflect the practicalities of Defense procurement needs and activities which result in most Defense procurements being accomplished by other than formally advertised methods, and also to reflect the various new types of contracts developed in recent years.

One would think that should have triggered the retirement of that particular ritual, but two and a half years later, the Commission on Government Procurement report stated:

> When competitive negotiations are the appropriate procurement technique, the statute should not require Government officials to indulge in expensive, wasteful, and time-consuming procedures to carry out congressionally authorized missions.

In its formal recommendations, the Commission's recommendation 3(b) said:

> Authorize the use of competitive negotiation methods of contracting as an acceptable and efficient alternative to formal advertising.

Senator Lawton Chiles of Florida and the Commission on Government Procurement took up the cause and have been doing battle with the RAN/D&F ritual since. He introduced S.1264, "A Bill to provide policies, methods, and criteria for the acquisition of property and services by executive agencies," early in the first session of the 95th Congress -- three and a half years ago. This bill would have terminated the RAN/D&F ritual by specifically authorizing procurement for competitive negotiation in cases where the criteria for procurement by formal advertising are not satisfied. The 95th Congress passed into history without action. Now Senator Chiles has updated the bill to S.5. Hearings have been held in the Senate but none have been held in the House as of this writing.

"The System" and the Brain Drain

With so much technical time and talent burned up in the RAN/D&F ritual and other demands of "the system," how much is left to do the hard technical work that has to be done to innovate new capabilities? While this issue has apparently escaped serious research, there are indications that the toll is much higher than generally realized.

In testimony to the Senate Armed Services Committee, Kelly Johnson, manager of Lockheed Aircraft's famous Skunk Works, addressed that topic. The following are excerpts from his testimony.(4)

> Senator Symington. That demand for justification, does that come from the branch offices of the service in California or wherever your plants are? Or does it come from Washington, or both?
>
> Mr. Johnson. Basically, it stems from the Pentagon, and they put their management systems into Wright Field and in the Navy offices. The thing I showed you here in the table about the progress reports required per month keeps hundreds and hundreds and in certain cases thousands of people generating paper which nobody reads.
>
> . . . .
>
> Mr. Johnson. It is not all that indirect. I have made constant surveys over the 20 years about what percentage of an engineering group actually is engaged in putting a line on paper, writing an analysis that has to do with the hardware. In 1956 I had an engineering department, California division, of 5,000 people. I found that 5.6 percent of the total time was spent in actually addressing the problem: How to make the hardware. I found out about 10 years later they were down to 3 percent. . .

In a humorous talk to an engineering management group, Dr. Robert A. Frosch, Administrator of NASA and former Assistant Secretary of the Navy (Research and Development), discussed the issue of how scientific and technical talent is consumed by "the system." "A question ... comes up regularly as I review programs, and it is one that all managers ought to contemplate," Dr. Frosch told his audience,

> . . . that poses some problems for me that I have never solved but am trying to tear into. I am presented with a project in which something is to be built. The output of the development is an object of finite size, 10 inches in diameter and five feet long with so many elements in it. I am told that work for the next year will consume $N million. So I pick whatever seems to be the going number for the cost of an engineer ... with his engineering support and divide it into the $N million and I discover that this finite object, of which we are going to build 4 and test 3, is suddenly surrounded by 500 engineers. I ask myself, "How do they all get their hands on the object?" What is it that all of these engineers are doing? How much of it in fact is productive work that has to do with the design, construction, and testing of the object and how much of it has to do with something else that is not a proper part of the engineering job but is somehow imposed by the Navy, or imposed by the Government, or imposed by our particular culture for doing engineering. From time to time I have been able to identify and demonstrate in a particular case that in fact about one-tenth of the engineers involved were in fact doing engineering in any traditional sense and the rest were writing each other memos.(5)

ATTEMPTS TO CHANGE "THE SYSTEM"

While nothing has been done to stem the massive talent hemorrhage of the RAN/D&F ritual, we do not say that nothing has been done. Substantial changes have been made, particularly in the process for acquisition of major systems, with emphasis on weapon systems. The thrust of most of these reforms has been an attempt to control cost overruns through strengthening of control by agency heads and the Congress.

In the 1960s, Congress and some of the Departments and Agencies within the Executive Branch came under increasing pressure from the public to contain the costs of major military and space systems. This criticism was particularly directed toward the Department of Defense (DOD). Robert McNamara, then Secretary of Defense, answered the critics by introducing a number of wide-ranging innovations into the government's system acquisition process. These innovations included the Program Evaluation and Review Technique (PERT), incentive contracting, the Planning, Programming and Budgeting System (PPBS), and several others;(6) all intended to give government program managers and contracting officers clearer visibility and tighter cost control over their projects.

This trend in introducing cost control measures certainly did not stop there. It continued throughout the 1960s with other concepts, such as Total Package Procurement and Life Cycle Costing, all designed to peck away at the source of cost overruns on major programs.

Then, in 1969, there was a flurry of "top-down" initiatives. In May, David Packard's memorandum(7) established the Defense Systems Acquisition Review Council (DSARC). Later that year, in July, the President and the Secretary of Defense commissioned the Blue Ribbon Defense Panel to examine the area of defense acquisition and management. Not to be outdone, Congress jumped on the bandwagon and created, by public law, the Commission on Government Procurement (COGP) to study and recommend methods for more economical, efficient and effective procurement.

These recommendations and reports by the Commissions were followed by others(8) that both mirrored the same concerns and reinforced the recommendations. Then, in 1976, the Office of Federal Procurement Policy (OFPP), under the jurisdiction of the Office of Management and Budget (OMB), issued the A-109 Circular(9) that translated the COGP recommendations into government policy concerning the Acquisition of Major Systems.

While these measures appear to have helped to control cost overruns, there are grounds for suspicion that the "side effects" may prove much more devastating than the "disease" they were designed to control. While schedule is continually referred to in the various documents, there is evidence that the acquisition process is lengthening.(10)

Selected Acquisition Reports (SAR) for major systems show the length of procurement cycles to be increasing. Major missile systems are now taking on the average of 61% longer to acquire than in

1971.(11) Aircraft, too, are taking longer to become operational and are "now (1976) reflecting about nine years to IOC compared with five and one-half years in 1971."(12)

We believe this case illustrates the general futility of attempting to reform "the system" through ad hoc "problem solving." In this case these actions have been of some utility in cutting cost overruns, but at the sacrifice of the combat edge which comes with achieving operational capability with new weapons while they still enjoy technical superiority over the weapons they must face in combat. The F6F Hellcat was a great weapon in early World War II but would have been a dubious asset if its development had been stretched out so that it was not combat-ready until Korea.

Who is responsible for the mess? We believe there are two answers to that question: "Nobody," and "Everybody." Bill McLean, father of the Sidewinder missile, was not the first to observe that "Success has a thousand fathers; failure is an orphan." However, McLean went on to explain why that is true for systems acquisition.(13) McLean held that you could always identify a "creative designer" -- Bill McLean for his Sidewinder, Ed Hinnemann for the A-4, Kelly Johnson for the U-2, Michelangelo for the Sisteen Chapel -- for the successful programs, but seldom for the failures. He held that the reason you have difficulty identifying the "architect of failure" is that there was no creative designer controlling those programs. Rather, the systems were the vector-sum result of a lot of influences; they were "camels" designed by committees.

If somebody offered a million dollar honorarium for the "architect" of the acquisition system to appear at this symposium, could anyone demonstrate that s/he qualified?

ON CONTROLLING AND RATIONALIZING "THE SYSTEM"

The real heart of our proposal for bringing "the system" under control is assignment of clear "design responsibility" for the acquisition system in its totality and for every identifiable subsystem of the overall system. We propose a "bottoms-up, inside-out" approach -- turn the improvement job over to <u>the people who are the system</u>; apply the basic approach which underlies the profitability of Proctor and Gamble, the productivity of Texas Instruments, and the reliability of Maytag appliances.

This powerful but simple process involves the following six steps:

<u>Step #1 -- Assign Accountability for Improvement</u>. The first element of getting organized is to pin down responsibility (and accountability) for the performance of the acquisition system and its subsystems. The basic rule is that the official responsible for day-to-day operations is also to be responsible (and accountable) for understanding and improving that part of the overall system through which his operational responsibility is accomplished.

In a "government of laws" it is not possible to delegate to each responsible manager full authority to alter the design of "his system." However, each manager can be held accountable for these functions:

- o Understanding his system
- o Identifying his "problems" or "innovation opportunities"
- o Solving those problems which can be solved with the knowledge, resources, and authority available to him
- o Taking action to bring the most important of the remaining problems to the attention of officials with the authority necessary to effect the problem's solution.

These accountable managers will be supported by teams from their organizations. The overall improvement organization will consist of an inter-related structure of improvement teams and should be built from the bottom up. The basic building block of the organization will be teams consisting of first-level supervisors and a half-dozen or so of his/her subordinates who actually do the nitty-gritty work of the system, e.g., getting out a $9,000 purchase order. Higher-level teams will be staffed by the leaders of the lower-level teams up to the top-level team for the overall acquisition system. Ad hoc experts will serve with the teams when a team believes their particular knowledge and skills are required.

<u>Step #2 -- Define Improvement Objectives</u>. The next step is to hammer out some coherent picture of the capabilities we want "the system" to have after it has been brought under control. As in development of hardware, we should define these performance objectives quantitatively where possible.

Before we can put numbers on our aspirations, it is first necessary to define the "yardsticks" through which we will define what constitutes being better for the overall system in its totality, and later for its subsystems and lower-level system elements.

Here are three yardsticks we propose for use in setting performance objectives for the macro acquisition system after it has been brought under control:

- o Assignment index -- a measure of the percentage of our nation's total supply of people qualified by training and experience to contribute to technological innovation who are in jobs where they can do so.

$$\frac{\text{TOTAL ASSIGNED TO DOER JOBS}}{\text{TOTAL -- DOERS + REVIEWERS, ETC.}}$$

- o Application index -- a measure of the percentage of the time of people in doer jobs available for actually doing the job -- the time left after the demands of "the system" are satisfied.

$$\frac{\text{TOTAL TIME AVAILABLE FOR DOING}}{\text{TOTAL TIME OF PEOPLE IN DOER JOBS}}$$

- o Time utilization index -- a measure of the percentage of elapsed program calendar time actually devoted to innovating new capabilities. This is total elapsed time less time spent "marking time" waiting for funds to become available, waiting for RFPs to come out, waiting for . . . .

$$\frac{\text{TOTAL TIME SPENT DOING}}{\text{TOTAL ELAPSED PROGRAM CALENDAR TIME}}$$

It is clear that we don't know enough at this time, in any rigorous sort of way, to establish usable quantitative objectives for the capabilities and costs of "the system," nor for its subsystems either. However, under the approach we propose, such objectives would be established by the inhouse improvement teams at some time during the improvement process.

<u>Step #3 -- Document the "As Is" System</u>. The teams will document the "as is" processes which collectively constitute the system. This will be done in a highly disciplined manner through use of flow charts and other readily available aids. The output of this process will be an explicit "model" of each team's system as it is, or was, before initiation of improvements.

Figure 1 is a simple model of a simple process. This is a multiple activity chart for a machine and its operator. Note that in this example there is considerable idle or waiting time. In fact, throughout the process, either the machine or the operator is "idle".

It is interesting to speculate on just what a multiple activity chart of a typical system acquisition process would look like.

Assume that for the sake of simplicity the model was limited to the following parallel activities:

- o Resource acquisition -- including the planning, programming and budgeting process within the bureau, department, OMB, two Houses of Congress, and the Presidency, and subsequent apportionment and allotment processes culminating in money available for obligation.
- o Program approval -- including all of the many milestone and other go/no-go decisions at all levels.
- o Procurement -- including all source selection and contracting activities.
- o Hardware development -- including all scientific and technical activity, after the Milestone Zero or program initiation decision, which is designed to contribute directly to the desired new capability.
- o Non-hardware system development process -- This involves the training of people, development of support capability, etc. -- all the non-hardware elements of the total system required to have an operational capability as differentiated from having only superb hardware of impressive "potential."

If we did a multiple activity chart model of a typical 20-year modern weapon system acquisition, how much of those 240 months would be all-out, moving-ahead, technical activity? What time utilization index would we find? Would it be as high as the 25% David Packard reported -- 2 years to get the planes "in the system"; 6 months outside the system? Do modern day acquisition programs take so long because of the inherent technical difficulty of achieving the capability objectives of those programs, or is much of that time wasted by the internal operations of "the system?"

<u>Step #4 -- Question Each Process as a Whole and Each Individual Step</u>. The team first asks <u>why</u> the whole process has to be done at all. If the process is judged to be necessary, the team will question the requirement of each individual step: "What is its purpose?" "Where should it be done?" "When should it be done?" "Who should do it?" "How should it be done?" The output of this process should be a collection of all the best alternatives for improving the process.

This step is typically a group activity where all the people involved examine the model from Step #3 and thoroughly question (Why? What? Where? When? Who? How?) the existing process as the collective creative capabilities of the group are energized to devise a menu of improvement options.

<u>Step #5 -- Define the Proposed Process</u>. The team selects from among the best of the alternatives explored in Step #4 to define the proposed system.

<u>Step #6 -- Sell and Install the New Process</u>. Under the traditional approach to change, selling the proposal involves convincing the people who must make the system work that it is a good idea. However, under the bottoms-up approach the people who must make the new process work are the ones who developed the idea and are therefore committed to it. Thus, in the bottoms-up approach, selling involves clearing the proposal with teams for interfacing processes and getting the hierarchy's approval. The installation process is relatively straightforward since the people who must make it work are thoroughly knowledgable about the new system and its supporting rationale.

MAN AND MACHINE CHART

OPERATION Facing Bosses (Old Method) SHEET 1 OF 2

MACHINE TYPE Milling Machine DEPT. NO. 1

CHARTED BY John Doe DATE

MAN		TIME		MACHINE
Walk to Tote Box return to machine. Burr edge of hole. Blow off machine. Pick up and replace spud clamp. Start Machine.	27	10 20	27	IDLE
IDLE	9	30	9	Milling.
Stop machine, remove part. Knock out spud.	15	40 50	15	IDLE
TOTAL	51	60 70 80 90 100 110 120	51	

SUMMARY	CYCLE TIME			WORK			IDLE			UTILIZATION	
	Pres.	Prop.	Saving	Pres.	Prop.	Saving	Pres.	Prop.	Saving	Pres.	Prop.
MAN	51			42			9			82%	
MACHINE	51			9			42			18%	

A. H. MOGENSEN — WORK SIMPLIFICATION PROGRAMS

Litho. in U.S.A.

Figure 1. Simple Multiple Activity Chart

Implementing The Program

Step #1 should be implemented throughout the acquisition system immediately. Orders should be issued to make every official accountable for both the efficient administration of his responsibility and for doing what he can to rationalize that part of "the system" through which he accomplishes his day-to-day responsibility. The subsequent steps should then be implemented in an orderly and step-by-step way. Limited scale application can be undertaken, followed by larger-scale application based on the lessons learned in the initial tests.

This "walk-before-you-run" approach is most important. If a decision is made to go immediately into fullscale application without first "building and testing some prototypes," the effort will probably fail. The truth of the matter is that not every organization can productively implement improvement through involvement without first making sure that some necessary prerequisites are satisfied.

Here are some of the conditions which will generally kill successful exploitation of improvement through involvement.

- Win-lose adversary relationship between management and the workforce. For improvement through involvement to succeed, it is necessary to have a high degree of mutual respect and confidence on both sides. Both sides need to see themselves as respected members of a team working together to achieve the common purpose of efficient accomplishment of the mission.

- Insecure managers who see suggested improvements as attacks on their competence. Organizations which most effectively exploit improvement through involvement are blessed with managers who are psychologically secure. They realize that improvements are always possible and are not devastated when their subordinates develop means for accomplishing a function at 10% of the old cost, or show how to eliminate the job completely. In

- View of wages and salaries as just another cost to be minimized. The unfortunate truth is that the typical government bureaucracy involved in the acquisition process is locked in a "war" in which management is trying to "win" by reducing the workforce, and the organization is trying to survive through exercise of an array of "weapons" and "tactics" including "backlog management" and "systematic work complication." If the workforce believes that their helping to improve productivity will cost them their jobs, there will be no significant improvement through involvement.

It is not necessary, nor even desirable, to promise that no jobs will be eliminated. It is necessary that workers believe that if they help eliminate their job that they will not thereby suffer loss of income. A number of conditions and actions can help to build this belief. For example, the initial implementation can take place in an organization with a rapidly growing workload where increases in productivity can be reflected in a reduction of the rate of growth of the workforce.

The first demonstration should be conducted in an area where improvements will be relatively easy to quantify. We suggest conducting the initial demonstration in the contracting aspect of the acquisition process. This is an area which is practically made to order for the use of flow process analysis, an extremely powerful improvement tool. Costs and benefits are also easy to quantify. Some possible measures include:

- Time for the overall process from the initial decision to initiate a procurement to the awarding of the contract, and time for completion of the various subprocesses, e.g., time from the procurement decision to the arrival of an approved PR (procurement request) and funds in a contracting organization; time from that event to promulgation of the RFP (Request for Proposal); time from promulgation of the RFP to award of the contract.

- Manhours for each process in absolute terms and per procurement dollar involved. For example:

  -- Manhours of technical personnel required for each phase of the procurement process

  -- Manhours of other government personnel, outside the contracting organization, required for each stage of the procurement process

  -- Procurement manhours (manhours of people assigned to the procurement organization)

  -- Manhours of vendors, broken down to show technical and support manhours, required for proposal preparation and other aspects of the procurement process

It is proposed that the test organization be selected from among volunteers. Prior to selection of the organizations to participate in the first round, sufficient briefings and other publicity must be presented so that procurement organizations satisfying the prerequisites discussed above are aware of the demonstration and the opportunity to participate. One approach might be to select a test organization from organizations nominated by members of the work force, since the competence, psychological security, and attitude toward people is so critical to the success of improvement through involvement.

SUMMARY AND CONCLUSIONS

We have proposed bringing "the system" under control and rationalizing it by turning the job over to the people who are the system. Why should any reasonable student of the acquisition process believe this approach will succeed when most other attempts to improve the system have only made it more burdensome and ineffective? Past efforts have not even been able to terminate the RAN/D&F ritual.

This bottoms-up, inside-out approach will succeed where all others have failed. Here are some of the reasons why.

Closed Loop Accountability. The approach will pinpoint accountability for understanding and improving that part of the system through which managers accomplish their day-to-day operational responsibility. This coupling of two responsibilities, "bureaucrat as administrator" and "bureaucrat as engineer" will make possible enforceable accountability for both functions, and will frustrate the standard tactic typically used to defeat outside-in, top-down attempts to bring about change. That is the "bureaucrat-policymaker game."

In this game the "changee," the official whose domain is the object of the change efforts of the "changor," the policy official or outside advisor attempting to bring about change, argues that the obvious inefficiency is due to regulations which he is obliged to follow. Since the "changee" knows far more about these regulations than the appointed officials for whom he nominally works, this tactic is very difficult to deal with.

However, when responsibility for both administering the system and understanding and improving the system are assigned to the same individual the tactic just won't work. If the official claims the contracts take so long to get out because of stupid rules, evaluation immediately shifts to his efforts to identify needed improvements and either make them or bring them to the attention of the officials with the requisite authority or resources to make them.

Total System Approach. The proposed approach provides the means to tackle the system in its totality, at all levels. By assigning improvement responsibility to each manager (assisted by his own work team), the total system is covered "bottom-to-top" and "wall-to-wall." Problems will be identified and solved at the lowest level where the requisite authority exists.

One of the reasons for the durability of the "let's reorganize" ritual -- a ritual probably more costly and counterproductive than the RAN/D&F ritual discussed earlier -- is that top officials, lacking the power to come to grips with the real problems, do about the only thing they can do ... shuffle the boxes.

Under the approach we propose, most of the beneficial effects, such as reducing the time (too often 6 months to 2 years) required to get out a contract, will be the result of the cumulative impact of very minor improvements by the work teams improving the details of the process. The minutes and pennies add up to years and millions.

With improvement opportunities identified and exploited at the lowest possible level, top level people will have the time and energy to deal with the system in its totality and really come to grips with the problems which can only be dealt with on a total system basis.

Track Record. What we are proposing is not new and untried. The approach is basically Frederick W. Taylor's "scientific management" as modified by Lillian Gilbreth, Allan Mogensen and others who recognized that the people who know most about a job, and are therefore best qualified to improve it, are the people doing the job. Here are some results of the approach in action.

- Texas Instruments, with its total participation in its People and Assets Effectiveness Program, has increased productivity by 15% per year while simultaneously reducing the costs of its products.

- Procter and Gamble, through its Deliberate Methods Change, has cut its costs by over $300,000,000 per year and achieved a pre-tax profit on sales dollar of 10%.

- During the mid-70s, an inhouse team from the Bureau of Drugs of the FDA overhauled the paperwork support associated with the process for approving new drugs. Working parttime (except for one member), the team completed the job in about six months. Results included a 59% drop in delinquent reviews, a doubling of reviews per reviewer, $3/4 million one-time savings and $1/4 million per year ongoing savings. Total consultant time (for training the inhouse team) was 15 days.

- In the early 1960s, VA 126, a squadron flying F9F Cougars at NAS Miramar in San Diego, reduced the time its planes were in scheduled periodic maintenance from 10 days and 275 manhours to 1 day and 100 manhours with a reduction in test flight deficiencies of over 80%. The squadron went on to run up successive annual all-Navy safe flight hour records.

- In the early 1960s, a small inhouse Navy team developed, documented, and applied the Integrated Logistic Support (ILS) concept which is now used throughout the Department of Defense.

Approach to Change. One of the major reasons improvement through involvement has been so effective is that it outflanks resistance to change. Under the approach we have described, change is proposed by the people who must make it work. People don't resist change; they resist being changed.

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PRODUCTIVITY IMPROVEMENT: A PROGRAM FOR SMALL PURCHASE BUYERS AND SUPPLY CLERKS

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ABSTRACT

Improved productivity among federal employees has been identified by the Office of Personnel Management as an important means for reducing costs for goods and services. While it is important for DoD to strive for cost-effective acquisitions, it is also important that attention be paid to the costs associated with procuring and distributing the acquisitions as well. This paper describes an R&D program, now underway, that is designed to improve the individual productivity of small purchase buyers and clerks in the Supply Department, Pearl Harbor Naval Shipyard. The basic method is to blend sound behavioral principles with the federal incentive awards program to make those rewards valued by workers contingent upon individual productivity. The effort includes: (a) identification of individual and group outputs; (b) determination of output measures; (c) establishment of performance standards; and (d) development of award formulas and supporting computer generated management information systems. Preliminary results of the program and a discussion of the implications for wider application are included.

The current climate of fiscal restraint coupled with the escalating costs of acquisition pose a tremendous problem for government agencies. One perspective to this problem has been expressed by Alan Campbell, Director of the Office of Personnel Management. He recently stated that "the central issue facing all levels of government is how to maintain services at a minimum cost, and productivity improvement has to be the answer." To deal with this issue, the DoD, as an activity of the federal government, must not only attempt to make acquisitions more cost effective but also reduce the costs associated with procuring and distributing the acquisition as well. Therefore, a prime candidate for cost-reduction in the acquisition process is the number of manhours required for procurement and distribution of material and/or services to end users.

This paper briefly describes a currently ongoing R&D effort to increase the individual productivity of small purchase buyers and supply clerks in the Supply Department of the Pearl Harbor Naval Shipyard. Only preliminary findings will be discussed here since conclusions must await completion of the project.

BACKGROUND

What is Productivity? Productivity, as defined here, is the ratio of measured work output to measured input. In the case of small purchase buyers, one example of an output is the proper completion of a purchase action, i.e., making a "buy" according to regulations and established procedures. In making a buy many things can be considered as inputs (e.g., labor hours, labor costs, material and supply costs, capital investiments, etc.), but because the Productivity Improvement Program (PIP) described herein focuses on improving the productivity of the worker, labor hours are most appropriate for evaluating workers. Thus, for example, one possible measure of small purchase buyer productivity is the number of purchase actions completed per labor hour.

What Determines Productivity? A number of factors are important in determining productivity. These factors can be divided into two broad categories (1): (a) those things that affect worker capability to produce output for a given input, and (b) those things that influence worker effort to use the capability available. Examples of things that affect capability include: (a) individual ability, skill and experience; (b) the level of technology (tools, equipment and methods); (c) the availability and quality of task related information, resources and raw materials; and (d) the physical conditions at the work place. Examples of things that affect effort to use the available capability include: (a) individual expectations about what can be done, what will happen if it is done, and how desirable it is to have these things happen; (b) organizational policy and practices; (c) task characteristics; and (d) peer group responses to productivity. The program described here attempts to alter individual expectations about what will happen if their personal productivity improves by making changes in organizational policy and practices concerning the administration of incentive awards.

Changing Trends in Incentive Awards. On 1 September 1954, the Government Employee's Incentive Awards Program was enacted to improve the efficiency and economy of government operations. Since passage of the Act, particularly in the past 8-10 years, there have been three fairly clear trends within the Office of Personnel Management (Civil Service Commission until 1978): (a) greater emphasis is being placed upon individual effort/performance programs, vis-a-vis the Beneficial Suggestion

Program to improve productivity; (b) monetary incentives are receiving more attention both in terms of greater distribution and award amount; and (c) program administration is becoming more decentralized thus allowing, though not encouraging, supervisors to make wider and more innovative use of the Program as a management tool. The project currently being conducted with the small purchase buyers and supply clerks represents one application of the Program and provides a clear demonstration of these trends.

THE PROGRAM

Savings and Sharing. The basic motivational principle involved with the supply study is the concept of "sharing the wealth." Performance standards are developed that essentially define the expected amount and/or quality of work required of an employee. When an employee chooses to perform at a level that exceeds what is expected (above standard) that performance "saves" production costs. In practice, the cost-savings result from the organization being able to either produce at a higher level with the same number of employees or produce at the same level with fewer employees. The Incentive Awards Program allows for a portion of these savings to be shared with the responsible individual(s).

Performance-Contingent Reward System (PCRS). Fundamental to wage and salary systems is the concept that fair market compensation should be paid to employees in exchange for what is considered to be a fair amount of qualified work (2). In most cases compensation is considered to be pay and benefits, and qualified work is thought of as output which meets quality requirements.

What happens though, when an individual or group exceeds productivity expectations? A Performance-Contingent Reward System (3, 4) provides a means to share the benefits of increased productivity with those responsible for the additional work output. This concept is not particularly new. The stated philosophy of the Incentive Awards Program in the federal government has endorsed doing this for quite some time, but has not provided the means to actually carry it out. What is new, is the sophisticated means that have been developed to measure productivity, compare it with what is expected of employees, and then determine the amount of reward for those who exceed expectations. In addition, the program attempts to minimize any negative consequences (e.g., reduction in force) that might occur when individuals improve productivity.

An important element in a PCRS is determining what work level is expected of employees. For example, the length of time a buyer is expected to take to complete each purchase action needs to be established. Such expectations are referred to as productivity standards. The success of a PCRS often depends on the quality of the standards chosen. Therefore, care should be exercised in developing the standards to be used.

Principles in the Development of Standards.

Fairness. In order for standards to have their desired impact upon motivation, it is important that they are perceived as fair and attainable. That is, the majority of the workforce must believe that it is possible for them to reach or exceed the standard. If they don't, any rewards associated with above standard performance will be ineffective. A variety of methods can be used to arrive at this fair estimate. Some of the traditional approaches include: method-time-measurement techniques; predetermined time methods; work sampling; historical records; and stop watch methods (5). While some of these methods are more objective than others they all use expert judgement to some degree. Choosing among them depends upon the nature of the work itself and the degree to which workers accept the method as a valid way of generating standards.

Complexity. The more variety there is in the tasks being measured, the more necessary it is to develop standards that reflect this variety. This is especially true when there is variability between people on the same job in the difficulty of the tasks they perform and/or when there is variability over time in the difficulty of performing each task. In either case, the development of performance standards becomes more complex.

With both the small purchase buyers and the supply clerks it was apparent that all purchase actions were not equal. There were both between-individual and across-time differences in the average difficulty and complexity of required actions. If standards were to be judged as fair, they would have to take these differences into account.

Earned and Expended Hours. How should the productivity of individuals on the same job be compared? One approach involves determining an expected or "standard" time for a worker of average skills to complete each particular product or output using available tools and procedures. Then, with the completion of each product or output, a worker "earns" the standard time for that output, no matter how fast he or she works. This index of completed work (output) is called Earned Hours. By itself, Earned Hours is not an index of productivity because it measures only the "output" portion of the productivity "output to input" ratio. The time spent in completing the output is considered the input. This input index is called Expended Hours. Earned Hours divided by Expended Hours is the index of individual labor productivity used in the present study.

Methods Used to Establish Earned Hour Standards. It was mentioned that there are a number of different ways to establish standards. Each of these methods has strengths and weaknesses. It is fair to say that no single method is always the best. Where possible, more than one method should be used to compensate for weaknesses in any particular method (6).

The establishment of standards for small purchase buyers and supply clerks began with identifying the actual outputs and any existing standards for these outputs. This process determined that completed purchase actions were the important measurable outputs. The only standards that could be found for these outputs came from a work sampling study conducted in the Purchase Division during 1971-72. The study was conducted by the Management Analysis Branch of the Supply Department as part of the Defense Integrated Management Engineering Systems Program (DIMES). Unfortunately, the study was frequently out of date because a number of changes had occurred in the tasks. Many of these standards, however, could be used as bench marks for comparing standards that were to be developed in the present study.

The method used to establish standards for small purchase buyers and supply clerks are each discussed separately below.

Small Purchase Buyer Standards. One important aspect of the tasks performed by the small purchase buyers not considered by the DIMES study was the variability in types of purchases or "buys" and the time required to complete them. A further complication was that a buyer's mix of tasks changes over time. Based on our initial work, it became apparent that if a PCRS was to be implemented, standards would have to be developed that would allow comparison between one buy and another and one buyer and another.

The reason the buyers' work was so variable was because different types of buys required different actions, and the more actions required, the more time a buy took to complete. Understanding this simple fact made it possible to determine statistically what characteristics of buys were associated with more actions, and therefore, greater time requirements. The statistical procedure used is called multiple regression. Previous work has demonstrated the value of this method for establishing standards for certain kinds of work (7). In this application the method solves for the "weight" of each buy characteristic in determining the overall time required to complete the buy. The greater the weight of the characteristic, the greater its impact on the expected time required to complete the buy. Over 1,400 different orders were analyzed to determine the relative weights of their characteristics. Based on this analysis, it was found that five characteristics were important in determining the time required to complete a buy. These were: (a) whether or not the buy was made with a purchase order; (b) whether or not the buy was over $500; (c) whether or not the buy required competition among workers; (d) whether or not special quality assurance provisions were required in the buy; and (e) whether or not the buy consisted of nuclear material (material certified for use in nuclear powered ships). Once the relative weights of these characteristics were determined, it was possible to set preliminary standards for making different purchases that allowed buyers to earn hours according to the type of work they were given. These preliminary standards were then compared with supervisor and employee estimates, past performance, and the general standards reported in the DIMES study. After adjustments were made to the standards on the basis of these comparisons, the final standards were established. Included in this final Earned Hours standard for each type of order was an allowance for the number of requisitions included on that order. This allowance increased the hours earned in proportion to the number of requisitions included on the order and was included as an incentive or a "sweetner" to encourage buyers to combine as many requisitions as possible on each order.

Ultimately the appropriateness of the standards was determined using two criteria. First, the relative individual standard times needed to be consistent with supervisor estimates, previous time data, and the number of actions required. Second, past individual performances should qualify about 30% of the buyers for some incentive award. This percentage was chosen to ensure that the majority of buyers saw the standard as attainable. When both of these criteria were satisfied the standards were judged acceptable.

Supply Clerk Standards. A large majority of tasks performed by the supply clerks in the Purchase Division were very similar to the tasks performed when the DIMES study was conducted. It was, therefore, possible to use these standard times as anchors for determining earned hours. The times allowed needed only to be updated and adjusted. This was done by adding new task categories and adjusting the old times as a result of comparing the old times with new supervisor and employee time estimates and performance trends. Observed differences could generally be resolved by identifying new equipment (e.g., IBM Mag Card typewriters) or new procedures (e.g., additional clauses being added to the orders) now being used in the tasks.

For tasks not included in the DIMES study, standard times were interpolated from established allowances based on similarity. For example, if a non-DIMES task required the same amount and kind of typing as a DIMES task, it was given the same standard. If it required more typing or copying it was given a proportionately greater allowance. Additional adjustments were made to allow for differences in the typewriters used in the division. The amount of this adjustment was based on differences in machine performance as reported by IBM (9).

Finally, additional time was allowed on the tasks requiring typing of requisitions based on the number of requisitions or line items typed and whether the task required special quality assurance or nuclear processing.

As with the buyer standards, the acceptability of the supply clerk standards was judged by comparing them with existing estimates and determining whether 30% of the qualified staff had been able to meet them.

Method for Paying Incentive Awards. A major step to establishing an effective PCRS is the development of accurate performance standards. Since the primary objective of a PCRS is to correlate award with

performance as directly as possible, a second step is to develop the administrative apparatus required to bridge the gap between an individual's performance and the actual receipt of a monetary reward that reflects the value of that performance. The "bridge" for the supply study is the Weekly Productive Efficiency Report (PER). This report is a computer generated printout and is the product of two coordinated efforts. The programming logic and system design required to produce the PER was developed by the Navy Personnel Research and Development Center while the programs were written by the Programming Branch of the Management Engineering and Information Office of the shipyard.

PER Inputs. Individual productivity input is provided by two documents, a Transaction Code Sheet (TCS) and the Personal Activity Log (PAL). The TCS is a modification of a standard form used in the shipyard to monitor material ordering status and was designed to input required productivity data while adding very little extra work to the existing reporting system. The TCS is prepared by a small purchase buyer whenever a buy/action is completed. The PAL is completed by the supervisor on a daily basis and contains a record of each employee's daily distribution of work and hours spent in activities other than what is reported on the TCS.

For a given week, those employees who spend a minimum of 30% of their time on measured work (work for which expended hours are credited) are eligible to earn hours towards an incentive award. A computer program accumulates each employee's hours earned for all tasks completed and hours expended on measured work. Each week, an employee's expended hours are subtracted from earned hours. The difference is multiplied by an incentive rate to determine the amount of the incentive award. It should be noted that on a weekly basis the award could be either positive (for hours saved) or negative (if performance was below standard).

Incentive Rate. Previous research has found that 30% is the minimum amount required if an incentive program is to be effective in increasing productivity (8), and, therefore, the amount of the incentive rate was chosen to be approximately 30% of the average hourly salary rates. What this means is that employees can earn 30% of what they would normally earn for each hour they save by their performance above standard. For example, if a buyer works for 40 hours and accumulates 44 earned hours, 4 hours would be saved. For each hour saved, the employee would earn his/her incentive rate of \$2.38/hour (.30 X 7.93) for a total of \$9.52. This employee would thus earn \$9.52 towards an incentive award (this actually amounts to 3% of salary for that week). At the end of two weeks, the weekly totals are accumulated (both positive and negative amounts) and the employee is awarded when the amount of the savings is greater than \$25. All negative accumulated amounts are dropped and any positive biweekly totals less than \$25 are carried forward to the next biweekly report period. The names of employees and the amounts of their awards are then forwarded to the incentive awards officer in the shipyard Industrial Relations Office for processing and payment.

RESULTS

Since the Performance-Contingent Reward System was implemented in December 1979, too little time has elapsed to draw strong conclusions. A productivity comparison was made, however, between the 12-week periods preceding and immediately following program implementation. The average productivity ratios for those periods were .93 and 1.10, respectively and statistical analysis indicates that the improvement was significant ($t = 2.11$; $df = 22$ $P < .05$). This pre-, post-implementation mean productivity ratio difference represents an 18% improvement.

Based on these preliminary findings it appears that the program is having a positive effect on productivity. Many questions remain to be answered, however, some of which are briefly described along with their implications for future R & D efforts in the following section.

DISCUSSION

Improving the productivity of federal acquisition employees by using financial rewards in a performance-contingent mode appears to be both feasible and potentially effective. Continuing evaluation of the program will help answer questions about the permanence of the improvement, its cost effectiveness, and its impact on other shipyard operations. The following questions also need to be addressed. Does the improvement in small purchase productivity increase material availability and consequently reduce ship repair and overhaul time? Will the employees involved continue to see the program in a positive way? Will the shipyard be able to avoid adverse actions against employees as a result of productivity improvement? Can the program be expanded by shipyard personnel to include other areas in the supply department as well as the shipyard in general?

If the program continues to show favorable results the implications are substantial. Improvements in the productivity of employees involved in the acquisition process can result in savings of staggering amounts of money. Savings can be used to accomplish things not now possible, or used to help reduce federal spending and balance the budget. What is now an experimental effort in all likelihood could very well become a common practice in the future.

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A NEW CONCEPT FOR MANAGING THE CONTRACT AWARD PROCESS

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ABSTRACT

Drawing on their experiences with creating, implementing, and operating rigid performance standards, the authors have developed a new tool to assist in managing the people charged with awarding contracts. The authors suggest using network analysis to model and simulate the contracting process. This paper describes the authors' perceptions of problems inherent in using rigid management performance standards; the development and capabilities of the proposed contract processing model; and possible applications that could benefit both the workers being measured by standards and the managers who must make decisions based on that measurement.

INTRODUCTION

We have observed that the performance of many contracting organizations with respect to awarding contracts is measured, in part, by comparison of actual contracting administrative leadtimes to a set of rigid standards which are based on such factors as type of contract and dollar value. For example, an advertised contract in AFLC is supposed to take no more than 90 days to award (Table 1). We believe that this method of performance measurement has three drawbacks. First, the standards are single point standards, which are difficult, if not impossible, to keep current. Second, the existence of such standards tends to force managers and workers to prioritize work based on the standards rather than the priority of the items being bought. Third, because single point standards average away individual contract problems, buyers may be motivated by the speed of turnaround at the expense of a quality product.

As an alternative to this method of performance measurement, we recommend using flexible, computer models of the contracting process as the basis for a performance information system. These models can provide realistic performance information at the MACRO level, usable workload information for the first line supervisor, and provide <u>all</u> managers with a sophisticated forecasting capability.

PERFORMANCE MEASUREMENT AND CONTRACTING STANDARDS

Contracting organizations - or for that matter, most organizations producing a tangible product - inevitably choose to measure performance by looking at some combination of product quality and quantity. The awarding of a contract document, for example, can be measured for timeliness and for errors. The timeliness indicator is the one we are concerned with here. In AFLC's case, for example, contracting leadtime - or time to award - has become one of the principle measures of effectiveness, and, in fact, even influences the way AFLC contracting organizations justify their manpower. Because performance measurement involves comparing actual performance to some yardstick, standards are needed.

Continuing our AFLC example, their current contracting standards had their beginnings in the late 1960's. Management developed processing standards for contract documents by first combining all contract actions into groups based on some form of common denominator. Such denominators included dollar value of the action, type of contract (i.e., letter contracts), ASPR (now DAR) requirements (i.e., definitization of letter contracts), contracting techniques (i.e., automated purchase orders), and even such qualities as whether a contract action was generated by a purchase request or not. Each category, or contracting cycle, was assigned a standard number of days for award. Some of these standards were easy to come by, such as the DAR requirement to definitize a letter contract in 180 days. Most, however, came much harder.

The "Delphi Technique," combined with actual performance data, was the principle means used to develop these standards. When a good target number was found, it was encased in a 95% confidence interval with the top of the interval actually identified as a not-to-exceed number. The predictable happened, however. The average performance within each cycle, over the years, began to creep towards the ceiling because each individual action used the ceiling as its own target. Besides contributing to this problem of increasing leadtimes, single point standards generate other problems, as well.

PROBLEMS CAUSED BY SINGLE POINT STANDARDS

Single point standards offer no relief to the buyer for peculiar circumstances on any given contract, such as a contractor who is a slow quoter, the need for special clauses (GFE, hazardous

Table 1. Contract Award Time Standards

TYPE	DESCRIPTIVE TITLE	CYCLE	DAYS
PR/MIPR Generated Actions	Advertised	1	90
	Two-Step	2	200
	Source Selection	3	200
	Small Purchase	4	50
	Negotiated (Under $100,000)	5	100
	Negotiated ($100,000 to $6,000,000)	6	165
	Negotiated (Over $6,000,000)	8	180
	Letter Contract Issuance	F	60
	Class IV Safety Modification	J	30
	Unpriced BOA Order Issuance	K	30
	Automated Delivery Order	L	10
	Delivery Order/Prepriced Call	M	25
	PR Generated Contract Modification	N	60
	Contract Modification Requiring Definitization	S	25
Non-PR/MIPR Generated Actions	Basic Contractual Agreement	A	55
	Provisioned Items Order (Modification)	P	10
	Non-PR/MIPR Modification (PMW/PMZ)	Q	25
	Non-PR/MIPR Modification (PMD)	T	25
	Miscellaneous J041 Input	Z	5
Definitizations	Letter Contract	W	180
	Contract Modification	X	180
	Unpriced BOA Order	Y	150

materials, etc.), deficiencies in specifications, or even funds availability. As far as top management is concerned, all these peculiarities average out to yield an organization's performance measurement; but for the buyer who had a succession of such problems, the single point standard can be a nightmare because he can be constantly late. As a result, pressure can exist for buyers to concentrate on moving delayed actions because they are delayed, not necessarily because they need moving. The problem becomes serious if trade-offs occur between urgent, on-time requirements, and delayed, routine requirements. Because of this phenomena, the possibility exists for a misplaced priority system to develop, based on speed of turnaround, not on urgency of need.

In addition to disregarding the actual priority of a requirement, a buyer might be tempted to trade away processing steps (quality) for speed. Since single point standards represent the sum of many unique events in the contracting process, the buyer can speed up the process by cutting steps. We're not saying that only single point standards create this environment - but they certainly contribute to it!

One final problem that we've found with single point standards deserves mentioning - and that is upkeep. How do we adjust the standards when contracting policies or procedures change? Take a small business set-aside, for example. Suppose we want to implement a policy to set aside all small purchases when two or more small business bidders exist. If we knew how many days in the existing small purchase standard were allotted to processing small business set-aside peculiar activities, we could estimate the frequency of occurrence of the new set-aside circumstances, eliminate the set-aside days based on the old procedures, and recompute the standard based on the new. But we don't know this information.

We've found that without detailed information on how a standard is constructed - on what activities make up that standard - every time an environmental change takes place, the original "Delphi Technique" must take place again, too! What would happen if the existing standards already addressed a problem and changes weren't needed? For instance, in our set-aside example, maybe the base from which the standard for small purchases was developed contained only set-asides. Although unlikely, it could have happened; and it would make changes unnecessary. Or perhaps the days allotted for set-asides ran concurrently with another, more critical and time consuming event, in which case no changes would be needed at all. The point is, we'd never know.

Experience has taught us that in building processing time standards for our contracting activities - where each contract has both unique and standard features - separate techniques and philosophy must be available to evaluate organization and individual buyer performance, and to facilitate system maintenance. This implies variable standards. Standards can be developed

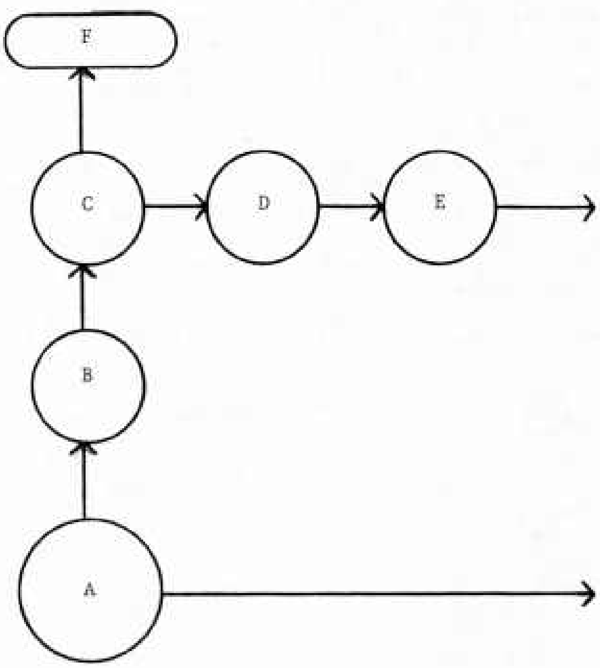
and applied, using modeling techniques, to offset each of the problems we've discussed.

PROCESSING MODEL TECHNIQUE

A modeling technique under development at HQ AFLC may provide the tool managers need to overcome the drawbacks of single point standards. The technique uses network analysis to model the contracting process. The number of models can range from one - a general, overall process model - to many, depending upon the level of detail desired. In the case of AFLC, it might be appropriate to have a different model for each of the cycles in Table 1. The models simulate the time consumed in awarding a contract document. This is done by simulating each individual event in the award process and its relationship to other events, accounting for concurrency, and totaling the result. Each model would contain all the possible steps or activities that could be taken in the award process for that particular type of contract. Associated with each activity would be a probability of occurrence, and a mathematical function describing the length of time the activity might take to complete.

Model Development. The technique has been prototyped at HQ AFLC using formally advertised contracts. The first step in developing the prototype model was to use a "Delphi" approach to construct a theoretical network relationship describing all the activities involved in processing an advertised contract. Next, a statistically valid random sample of contracts awarded during one year was drawn from command activities. This sample was used to refine the initial network by adding activities and events not previously identified, deleting activities with a negligible probability of occurrence, combining or further discriminating activities, and readjusting relationships. Figure 1 shows a small portion of the final network, representing the initial receipt and review of a purchase request in the buying office. In addition to helping define the network, this sample was used to develop activity characteristics for simulation purposes.

Each activity was first assigned a probability of occurrence based on the frequency within the sample. These probabilities were then examined and adjusted to reflect such things as dependence on previous events. Each activity was also assigned a probablistic descriptor of the time required to accomplish the task. These descriptors ranged from constant values, to random probabilities within a range, to statistical relationships defined through curve fitting techniques. Table 2 lists some examples of activities and their descriptive characteristics.



ACTIVITY	DESCRIPTION
A	PR Prescreening
B	In Transit Time
C	PR Rework by Initiator
D	In Transit Time
E	Secondary Review
F	Stop: PR Cancelled

Figure 1. Network Example

Table 2. Sample Activity Parameters

Activity	Probability of Occurrence	Time Consumed (In Days): Type of Distribution	Possible Range
PR Prescreening	1	Normal Curve Mean = 7.77 St. Dev. = 5.58	2-27
Pre-Award Survey	.1123	Normal Curve Mean = 20.60 St. Dev. = 9.67	6-42
Bid Verification Required	.2494	Uniform	6-20

Once the network relationships were finalized and all activity descriptors were developed, they were integrated using a special computer program designed to use the information to actually simulate the award of a formally advertised contract.

Network Model Capabilities. The simulation program used is extremely flexible. Random numbers can be generated for all activity characteristics to achieve a fully simulated contract award, or fixed values for known characteristics can be included to simulate an actual document in process. The model can be easily modified to add or delete activities and change characteristics, thereby simulating changes in the contracting environment.

In addition, the model identifies the time consumed for each activity, the total time consumed for each simulation, the simulation critical path, and summary statistics for multiple simulations. Figure 2 shows the results of a sample simulation.

Summary statistics for each activity after multiple runs include frequency, number of times on the critical path, and a graph showing frequency versus time consumed. The data provided by the model gives a practical basis for a new approach to managing the contract award process in AFLC.

BENEFITS OF THE MODELING APPROACH

Using the model as a management tool would be difficult - not because of technical problems but because of personnel "mind sets." Under a single point standard philosophy, if a standard was 50 days and a section chief's monthly average was 50 days, he was happy - even though when you stop and think about it, half of his contracts could have been late. Taking this thought one step further, a lot of buyers in that manager's section may have been tormented by late awards during the month, and yet the section chief was happy with his 50-day average processing time. The model technique can provide something for both the buyer and section chief, as it does away with this concept of the same number being a standard for an individual action, as well as a standard for the average processing of many actions.

Use of the model can eliminate the idea of "late or on time." No single action would be measured against a particular number. Rather, each action would be viewed as having a probable processing time based on the complexity of the action. A buyer would be given an estimate of the probability of his action falling within a statistical curve describing all actions of that general type, rather than a single point for comparison. For instance, if the mean of the curve for small purchases was 50 days, and a buyer completed an action in 60 days, the computer would tell him (and his section chief) his probability of taking 60 days based on his particular contract. If this probability was greater than zero, and the buyer had experienced unexpected delays, his performance would be viewed as acceptable. Under the old concept, regardless of the nature of his particular action, his performance would have been viewed as deficient simply for being ten days late. As far as the section chief is concerned, he could look at such probabilities for an individual contract or he could compare his section's total performance to the model. That is, he could ask the question "Could my contracts have been awarded in the times actually experienced and still have come from the population?" The computer would fit his section's actual performance to the model's predicted curve; and if the answer was "no," the model could then tell him which of his contracts pushed him outside the acceptance levels.

The advantages of this technique are that peculiarities in the contract process are considered by the model and, even though their probabilities of occurrence may be low, the section or buyer experiencing them can still be considered in tolerance. The emphasis is no longer "late versus on-time" because each contract actually has its own standard, based on the complexities encountered. Speed no longer is the primary consideration; the incentive to cut corners (reduce quality) in the interest of time has been removed, since the model considers all activity necessary to complete the action. Of course, fast turnaround is still desirable, but it would be up to managers to determine where emphasis should be placed - rather than having an artificial, inflexible standard do it for them.

Each contracting activity could also be compared to its own historical distribution. No longer would one common standard have to be the only way to judge performance. An activity's performance

CRITICAL PATH ACTIVITIES FOR SAMPLE CONTRACT AWARD

Order of Occurrence	Activity	Duration (Days)	Pct of Critical Path
1	PR Prescreening	16	16.69
2	Small Business Coordination	11	11.80
3	Solicitation Typed	8	8.39
4	Solicitation Review	1	1.07
5	Solicitation Reproduction	1	1.07
6	Solicitation Distribution	1	1.53
7	Bid Preparation Time (By Contractors)	30	32.19
8	Bid Time Extension	1	1.36
9	Formal Bid Opening	1	1.07
10	Bids Forwarded to Buyer	1	1.07
11	Funding Requested	2	2.14
12	Award Typed	8	8.80
13	Award Reviewed	5	5.37
14	Award Retyped	3	3.21
15	Award Reproduced	1	1.07
16	Award Distributed	3	3.14

OTHER ACTIVITIES	Duration
Minor Bid Discrepancy Processed	4

TOTAL TIME FOR ITERATION IS 93 DAYS

Figure 2. Sample Simulation

could be compared to its own historical model - with a resulting capability to analyze environmental changes applying only to that activity.

Maintenance of these models is no real problem either. Because the model is a network of contracting activities and events, a change in the environment can be compensated for by estimating what activities and events are affected, substituting new time and probability of occurrence variables for these changes, and then letting the model simulate a new standard distribution. The guess work - although not totally eliminated - plays a much smaller part in such revisions than in the old "Delphi Technique" of coming up with a totally new number.

With a little imagination, the simulation could be used for such things as studying the effects of expanding, contracting, adding, or deleting events and activities from the contracting process. We've also been able to do some work-in-process forecasting with the model in a test environment. Results show that the model has the potential to tell management when it is likely that on-hand work will not be completed consistent with historical performance parameters, or even if a particular contract is getting into trouble.

A final benefit of the model is that it provides the manager with a structured picture of what he's managing; something he's never had before. As a result, the potential exists for problem isolation and identification at a much lower level than ever before. Previous methods allowed us to make generalized statements, such as "It's taking too long to get solicitations out," but finding out "why?" took more time and manpower than managers could afford. The model can point out the direction that should be taken in finding out "why." For example, the prototype model on advertised contracts showed, by critical path analysis, that the processing of contracts which exceeded the 90-day standard was driven by the necessity to request and reproduce additional bid sets for prospective bidders prior to distribution of the solicitation. Everyone knew that this activity was necessary, and that it had some impact. But until the process was reviewed in the structured environment that the model provided, the extent of that impact was unknown.

The model recognizes that contracting lead time is still important, and it can help to control leadtime problems by giving management some degree of realistic "how goes it" performance information. It can provide this data in time to take preventive action, rather than having to react to an individual problem after the fact, or address overall problems without a guide for where to begin.

SUMMARY

Use of modeling and simulation to develop contracting performance measurement systems could alleviate problems with single point standards. The models can be modified to reflect changes in the contracting environment simply by adding or deleting activities and/or changing appropriate parameters. Additionally, replacement of single point performance standards by variable standards would recognize that not all contracts in the same category take the same amount of time to accomplish, and would allow managers to prioritize work by factors other than administrative leadtime, such as quality or urgency of need.

PRODUCTION ORIENTED PLANNING

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ABSTRACT

The paper is a summary of the planning and production control manual published recently by the Bath Iron Works Corporation in cooperation with the Maritime Administration as a part of the National Shipbuilding Research Program. This program seeks to improve productivity and thereby reduce differential subsidies in commercial ship construction. The techniques explained in the manual are basic, and apply to nearly any industrial activity. Research efforts are often restricted on one facet of a large and complex undertaking where one aspect is probed in depth. Here we have the antithesis. Whole shipbuilding systems are embraced and evaluated on their contribution to the total productive effort. Intended users of the manual - principally middle-level shipyard managers - are exposed to proven techniques for productivity improvements through the use of engineered labor standards. Concurrently, the manual provides a macroscopic view of shipbuilding somewhat beyond the normal purview of the intended user, a perspective that can aid in understanding how all the contributing pieces fit together.

APPROACH

Shipbuilders generally agree that intelligently controlled application of four basic resources - manpower, material, facilities, and time - is the key to minimizing ship construction costs. Each shipyard, indeed each industrial activity, has a system for planning and production control. The question is whether these systems are adequate to provide the cost pay-back and benefits that are possible through effective resource planning, budgeting, and scheduling, along with associated performance measurement and evaluation controls.

The Manual on Planning and Production Control for Shipyard Use should help to answer that question. The basic theme and subtitle is Production Oriented Planning, where planning for the use of resources is oriented squarely in line with the basic goal of the shipyard, which is to produce quality ships on time at a profit. The total shipyard effort then has the unity of purpose essential to success in a venture of such magnitude.

THE NATURE OF SHIPBUILDING

There are basically three groups of people in the shipyard that have to be recognized and dealt with to produce a coordinated effort:

- Those <u>doing</u> the planning
- Those <u>using</u> the planning
- Those on the <u>fringes</u>

Those <u>doing</u> the planning obviously include the traditional planning department, but keep in mind that detailed design and engineering actually dictates production methods through construction details and specifications. Those <u>using</u> the planning are the entire production force. With well-thought and reasonable plans, the production force can <u>and will</u> operate smoothly toward on-time completions within budget. Those on the <u>fringes</u> include the purchasing people who must have material on hand to support production, and the personnel people who must hire the correct number of skilled craftsmen to support production.

The four basic resources with which a shipyard deals in commercial ship construction are:

- Facilities
- Time
- Manpower
- Material

Of these four, the first two are essentially outside the realm of the middle manager. Facilities are usually fixed for the duration of a contract; any changes encountered are most likely part of an overall plan already considered. Also, time - in terms of project length - is fixed when the contract is signed. This is not to say that time and facilities are not vital considerations to a successful operation; rather that they are long-term variables that are more a function of upper management.

This leaves just two major resources to be considered during contract execution: manpower and material. Manpower considerations include general shipyard requirements by craft on down to individual job requirements. Material is usually called out by contract specifications; however, seeing that it arrives on time and is properly identified for installation by production is truly a <u>planning</u> function.

By the very nature of the business we are in, the planning process is an iterative one that develops more detailed information as time goes on. Five levels of planning, ranging from a general operations plan down to detailed individual job planning have been identified (Figure 1). Depending on the complexity of a given job, the actual number of levels could be expanded or combined to suit the particular requirements of the project.

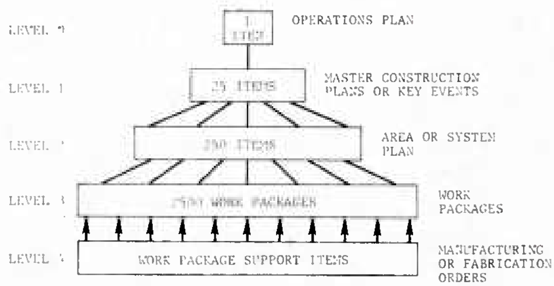

Figure 1. Simplified Planning Pyramid

The highest level of planning is called Level 0 and occurs prior to contract signing. It is at this level that top management decides whether or not the project will be taken on at all, which graving dock or floating drydock will be used, and what project duration (delivery) will be established.

Level I planning is the first level accomplished after contract signing, the major output here being a key events plan. Key events would include such items as: ship arrival, dock, undock, dock trials, sea trials, delivery. This is obviously an oversimplified list, but serves as an example. Level II planning consists of developing area (zone) and systems plans. Level III planning develops the work packages and Level IV develops the fabrication and shop orders to support the work packages.

As each level of planning is accomplished, it must be checked to make sure it does not conflict with the previous level. If it does, the lower level plan must be adjusted. If a lower level plan cannot be adjusted to fit an upper level plan, then management attention is necessary to resolve the problem.

It might well be noted here that a recent technology survey of the U.S. shipbuilding industry concluded that while U.S. shipyards are superior to their foreign counterparts in upper level planning, they are severely lacking in lower level planning. The survey further concluded that the key to any significant productivity gain is through improved Level III and IV planning and control.

The four underlying problems facing the planners, and indeed the entire shipyard work force, are easy to label but difficult to resolve. They are:

- Workload forecasting
- Resource utilization
- Schedule adherence
- Budget compliance

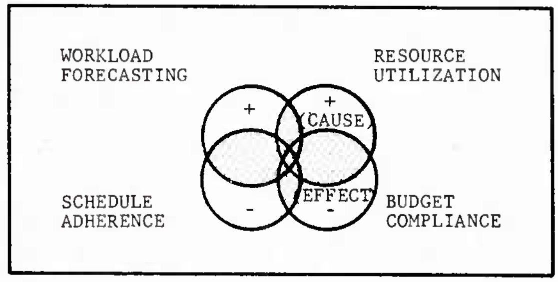

Figure 2. Interrelated Problem Areas

These four problem areas have several elements in common with each other, and therefore require treatment as an interlocking set (Figure 2). This requirement is actually an opportunity; the more overlap the better. Large overlap is a reflection on an efficient, well-directed, and well-executed process.

SEEKING IMPROVEMENT

Every shipyard, in fact every manufacturing and construction company, has some sort of planning and production control system. Some are primitive while others are complex; but every company has one. In reviewing an existing system to determine if improvement opportunities should be sought, two questions arise:

- How effective is the current system?
- What does it cost to operate it; that is, how efficient is it?

The essential purpose of a planning and production control system is to control project cost and duration. Accordingly, the performance of the planning and production control system itself needs to be measurable in terms of the extent to which actual production operations adhere to schedules and budgets.

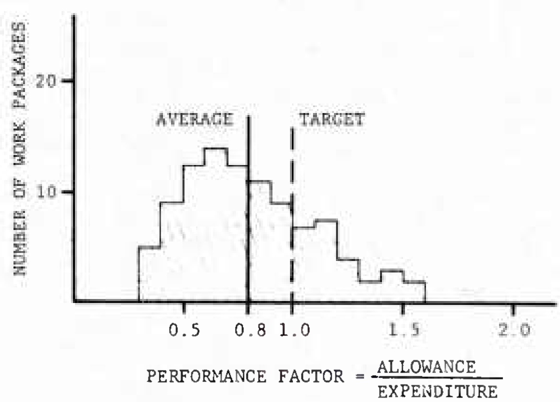

Figure 3. Average of a Distribution

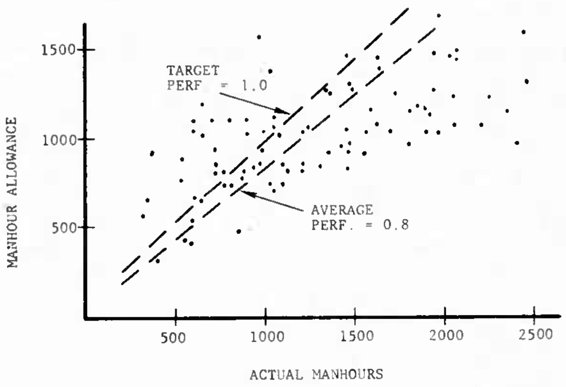

Figure 4. Variance of a Distribution (Scatter Diagram)

How well the planning and production control system is performing can be determined by looking at the variance as well as the average when comparing actual expenditures to planned expenditures. The average (Figure 3) will show whether the project is proceeding within planned cost and duration while the variance (Figure 4), or the spread of actual performance around the average, provides an indication of whether there is correlation between planned and actual performance. If there is little correlation, that is a large spread or variance, this is a strong signal that something is seriously wrong with the planning and production control system itself.

Scatter in performance is bad because it is caused by factors which contribute directly to excessive project costs. Early, as well as late, completions tend to increase project costs. Early completions create extra handling and storage costs, while late completions can impact overall project performance.

For discussion's sake, assume there are four production steps in the repair/overhaul of a ship:

- Parts fabrication
- Parts installation
- System hookup
- System activation

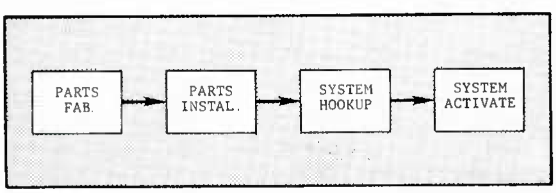

Figure 5. Simplified Ship Construction Sequence

These steps happen sequentially (Figure 5), so a late completion in one step can mean a late start in the next. If there is little correlation between planned and actual performance for each step, then approximately half of the jobs for step one will finish late.

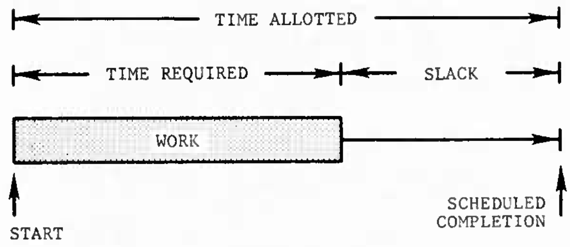

Figure 6. Slack

In order to minimize disruption of the next step in the production sequence, slack time is introduced between each step (Figure 6). Slack is used to absorb the late completions prior to scheduled start-up of the next job. If the amount of slack is too small, then the next job will start late, which of course increases the probability of a late completion. This, in turn, has a ripple effect which continues until the <u>whole project</u> becomes late, causing costs to rise above expected values. If, on the other hand, enough slack is introduced so that the late completion of a prior task has no effect on a successor task, then the entire project duration is probably <u>too long</u> and therefore too costly.

A shipyard must be cost-competitive to win contracts and stay in business. This can be done by reducing the variance between planned and actual duration, which in turn permits reduction in slack. A certain amount of slack is always necessary, but an objective must be to minimize the amount necessary to keep project costs competitive, and at the same time keep the difference between planned and actual costs within manageable bounds.

Refer once again to the simplified process flow (Figure 5) where Parts Fabrication precedes Parts Installation, and assume that average performance is on target for Parts Installation. It can then be concluded that there is enough slack in the scheduled durations of the jobs loaded on Parts Fabrication that Parts Installation performance is independent of Parts Fabrication.

If project time, and therefore cost, is to be reduced, then the amount of slack in the schedule must be reduced. This could be done directly by scheduling the start of Parts Installation jobs closer to the scheduled completion dates for Parts Fabrication. But as slack is removed, Parts Installation performance will become more strongly influenced by Parts Fabrication. Parts Installation performance will begin to deteriorate. Scatter will increase and the average will begin to show a bias toward lateness.

There is a much better way of compressing the schedule that avoids disrupting shop operations. That is by first reducing the <u>scatter</u> in Parts Fabrication performance, and <u>then</u> reducing the slack in the schedule. This suggests that the proper way to approach compressing project time is to focus on the first shop (or operation) in the construction sequence; improve performance there; and then elimin-

ate as much slack from the inter-shop schedules as possible without significantly disrupting operations in the next shop. Following this procedure, each shop would be attended to in sequence until all shops or operations had been treated.

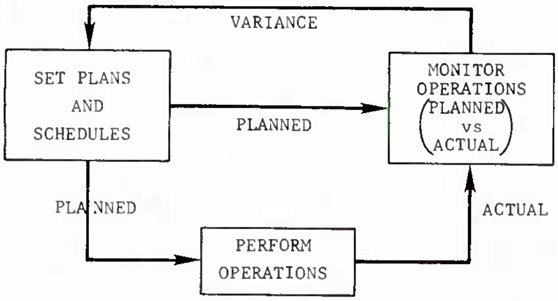

Figure 7. Information Feedback Loop

In order to improve performance to schedule, which is equivalent to reducing the variation (spread) about the average, the causes of the variations must be identified. In doing so, recognize that a planning and production control system is really a type of feedback control system (Figure 7). Scatter in performance is measured by monitoring operations, and results from a comparison of information that comes from two distinctly different sources:

- Output from the planning and scheduling function, which provides the planned values.
- Reports from, or measurements of, the operations themselves, which provides the actual values.

If there is a wide dispersion in actual performance about the average, the cause may be either the planned values from planning or the actual values from production, or some combination of the two.

To truly improve the system, it is essential to assume that something is wrong with the planned values, and only charge production with causing the problem when convinced that the planned values are absolutely correct and beyond reproach. A wide variation in performance indicates that the system is not really exercising control, so there is a good and logical reason to suspect planning before suspecting production.

With perspective focused on the planning and performance monitoring of the system, rather than on production, the actual values can be used to measure the performance of the planning function. Assume that each job is manned at the optimum level and takes exactly as long to complete as it should have taken; that is, production performance is perfect. The problem then lies not with production, but with planning, which budgeted the labor hours and duration for the jobs. Time and labor allotments for some jobs were too small, for others about right, and for still others too much. A broad spread suggests rules used for estimating labor content and job duration are quite unreliable and should be improved.

The jobs to which budgeting rules are applied must now be examined to see if there are any significant differences in work content which can explain why budgets are reliable for some jobs and unreliable for others. Assuming that significant differences in work content are found in the jobs, the next thing to do is to adjust the budgeting rules (standards) so that the budgets developed by the new rules approximate more closely the labor and time expenditure averages collected for the jobs. Finally, labor and time budgets for future work are established using the new rules. Time and labor expenditures are collected as the jobs are released to the shops, and the analysis process is repeated to check for improvement.

ENGINEERED STANDARDS

The principal ingredient needed for this process is a set of engineered labor standards. They provide a more accurate assessment of work content which in turn narrows the dispersion in work performance. Engineered labor standards are a norm against which actual performance can be measured, and the need for corrective action can be recognized. Control can then be measured.

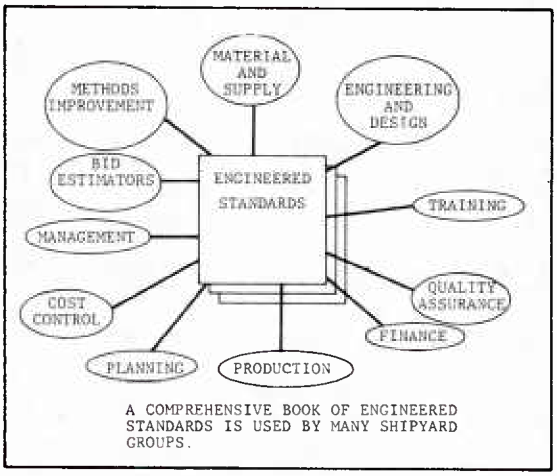

Figure 8. Use of Engineered Standards

Once they have been developed and published, engineered standards have many uses. The extent to which engineered standards are used by the various components in a shipyard (Figure 8) can provide a measure of the advantage gained by having produced them originally. The more use they receive, the more return on investment will be accrued.

Producing a set of engineered labor standards is neither inexpensive nor easy, although it is straight-forward. More difficult to obtain is a rather delicate ingredient essential to the successfull generation and use of engineered standards. This ingredient is the wholehearted support of the production people who are most heavily affected by engineered standards. Gaining this support depends

on seeing the production process from the point of view of the production people that carry it out. Since they are the largest controllable variable in the shipbuilding effort, alignment of planning and support with their needs seems likely to produce the most efficient and effective overall arrangement for the shipyard.

The first requirement is to know what the production worker can do when he is allowed to do it. Fortunately, shipbuilding is accomplished through repetitive performance of several processes and methods. Each process, or at least most of them, can be isolated and examined to find out how many workers are needed over what period of time, what access requirements must be satisfied, what material is needed, what facilities and equipment are involved, and what other ingredients are necessary for successful performance of that process. Non-productive time that is part of the process can also be included, like lunch breaks, personal time, setup and breakdown periods, and similar items that go to make up the real performance of that process under actual conditions. Once all this information is collected, it must be put in a form that is easy to use the next time around. This will provide a basis for improving the information as process performance improves, and also allow use of the information by other people in the shipyard.

Ideally information should be available on each and every process and method used in the shipyard, but in reality there may never be a complete set. The more information that is available, though, the more that will be known about what the production people can produce. A reasonable benchmark is about 75-85% of production operations covered by detailed information.

Next, this information must appear in the drawings and schedules that production will use. Since the pieces of information are based on what production can actually produce, then the compilation of the pieces in the plans and schedules should accurately reflect how the work will really be done. If the plans and schedules both fit the pieces together without gaps or overlaps, without conflicting demands for work sites or facilities, do not demand people who are not available and conversely keep everyone busy, and material supplies keep up with demands, then an effectively executed production effort should result. Success depends on how good the budgeting is, and how good the supporting items are - like material being at the right place, at the right time, in the right quantity, and in the right condition. These are all things that production people should not have to worry about.

THE MACROSCOPIC VIEW

Budgeting the four resources as described above, through use of engineered labor standards, can produce results that have improved accuracy. More accurate budgets can form the basis - a production oriented basis - for more accurate scheduling. More accurate scheduling will result in less variance between planned and actual performance, because planning and scheduling are based on what the production department can actually produce.

- Schedule adherence will be improved, since there is less difference between planned and actual performance.
- Budget compliance will be improved, since the budget is more closely aligned with what the production department is capable of producing.
- Resource compliance will be improved, because the planned usage is based on what production will actually need to do work.
- Workload forecasting will be easier and more accurate, because contract backlogs will be reduced by improved schedule compliance, and a smoother flow of production effort is easier to predict.
- A more reliable basis will exist for measuring and evaluating performance, and for identifying corrective actions, because the variance in performance is reduced.
- Since production is performing better, less time will be spent by production management in explaining why the target was missed. This leaves more time for useful effort like doing the work, improving the processes, and further enhancing the performance posture of the shipyard.

From the production point of view, such a system provides a way to reshape planning and scheduling to better represent what production can actually produce. And with production people participating in the generation of process standards, and agreeing with their content before they are established, the risk involved is small. The key, of course, is more accurate and more reliable information on which to base planning and scheduling actions. This will benefit production most of all.

The whole is the sum of its parts. So it is with shipbuilding, except that there are two different aspects to successfully making a whole: (1) how well each piece is produced; and (2) how well the pieces are joined together. The first aspect is heavily influenced by production; and the second aspect is heavily influenced by planning. The two together make up the main effort which eventually produces the ship.

Making each piece of the whole depends on the application of resources according to a certain process or method. Many individual processes are involved in building a ship, most of them repeated over and over again. It may be at a different place, at a different time, under different circumstances and influences, but it is the same process.

Since many processes are repetitive, it is important to have accurate information on each one, e.g., how long it will take, how many people are needed, how much material is involved, how long it will tie up a facility or piece of equipment, and similar performance information. It is important that this information truly and accurately reflects the production work needed to carry out the process. Then, and only then, will this basic building block be available to use in planning for future performance of the same process.

This basic information contained in engineered labor standards also allows refinement and improvement of the production process itself, but this aspect is really a side benefit and not the vital one. Certainly process improvement is important, but performance prediction is more important. Imperfect performance is less important than not knowing what performance will be. Credibility is based on truth, not perfection. Planning must be based on what production can be expected to produce. There is a time and place for production process improvement, but it is definitely not in the middle of the planning process.

Putting the pieces together is where the pay-off comes in a production oriented planning system. When there is confidence in the ability to produce the pieces as planned, the assembly of the pieces can be more closely meshed. Timing can be tighter, and much improved over what it had to be to accommodate the unknowns. Of course there will be pieces of the effort that do not lend themselves to treatment as measured processes, but far fewer than might be expected. At the very least, the so-called unknowns can be minimized and their impact on the system thereby reduced.

The first and most significant advantage will occur in production where the plan becomes more performable. It is carried out with less frustration and lost motion on the part of the workers, and with less disruption and delay in the overall effort. As other areas are added to the system, confidence in the planning grows and so does the efficiency with which the work is done.

The planner now has better tools for creating the plan. He can predict quite accurately what production can produce. He can select the appropriate pieces of process information and put them together to form the plan for the package of work. Since the plan is composed of reliable and agreed-to pieces, the risk of production rejecting it is greatly reduced. This enables more confident planning, and the planner is encouraged by the better reception of his product.

As work continues, there is a better basis for in-process adjustments to keep matters on track. Vaiance measurements have a reliable reference point. Visibility of progress is improved. Determination of corrective actions is more rational; so is the exercise of in-process control, and measurement of response to it. The system can now be extended and fine-tuned for further improvements, as long as the return on investment remains favorable.

The cost of improvement must be justified. The emphasis thus far has been on improving production efficiency by improving the effectiveness of the planning and production control system. If there is a wide variation between planned and actual performance, the system is not doing much controlling and probably needs improvement. The real question that must be addressed is how much should be invested in improving the system.

The answer to this question derives from the fundamental objective of the planning and production control function itself, which is to reduce the cost and duration of projects to competitive levels, and then keep them there. How much should be invested depends entirely on the expected return in terms of reduced project costs and durations. Theoretically, there is an optimum level of planning effort where increases in planning costs are exactly offset by reductions in cost of the productive effort (Figure 9).

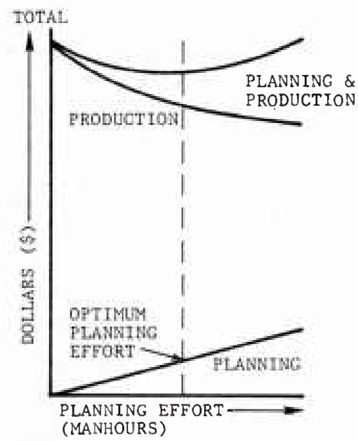

Figure 9. Macroscopic Cost Profile

To find this theoretical minimum is difficult, to say the least. There are two reasons for this. First, the exact cost/benefit ratios are not known. Usually the best that can be done is to record current values, make a change in the amount of planning done, and then record the results from the change. But this is difficult for the second reason. The cost of the planning effort can vary widely depending on the efficiency of the system that implements it.

The central point here is that considerations of efficiency and effectiveness are of paramount importance in achieving a proper balance between the planning and production control system on the one hand, and the productive effort it supports on the other. In searching for this balance, three points must be kept in mind. First, production usually works at a steady level of effort - assuming a smooth flow of plans, instructions, material, and available worksites. This suggests, as the second point, a refusal to recognize the day-to-day influences and difficulties of the real world which cause disruptions to the orderly progress of work.

Regarding these first two points, it might be argued that since disruptions are real, and the level of production effort is not truly constant, a more refined measurement of production performance should be used. Things can become too clouded with too much information, however. In the final analysis, these disruptions will be smoothed out. Conversely, care must be taken to avoid too gross a measurement such that the data produced is not useful. The correct degree of detail for a particular shipyard or industrial operation will be readily apparent after the first or second trials.

The third point is that the effects of production improvements do not appear immediately upon establishment of planning improvements. There is a time delay, perhaps as much as a year, between better planning, and improved production performance because of the better planning. Curves like those of Figure 9 are actually skewed in time, a feature which is not easily illustrated. Nevertheless, this macroscopic approach can identify whether additional investment in planning will continue to produce savings in production costs.

EXPERIMENTAL INSIGHT

An experiment was conducted at a steel fabrication plant of a shipyard to see whether application of the concepts outlined here would produce improvements in planning and production control. Actual "before and after" data was collected.

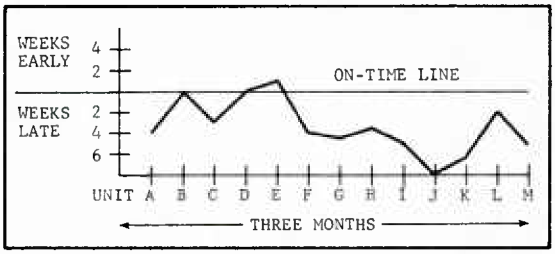

Figure 10. "Before"

Before the experiment, the fabrication shop was loaded using an historical factor based on tons of steel processed per week (Figure 10). While on a gross average across the whole ship this number was good, on a week-to-week basis it was irrelevant. During a three month period 62% of the units were more than four weeks late, yet the throughput in terms of tons-per-week was fairly good.

The first item that was examined was production performance, which seemed to fluctuate wildly with both good and bad performance. There was a great deal of variance between planned and actual performance, yet the average was quite good. The most likely reason for this would be poor planning rules, or standards.

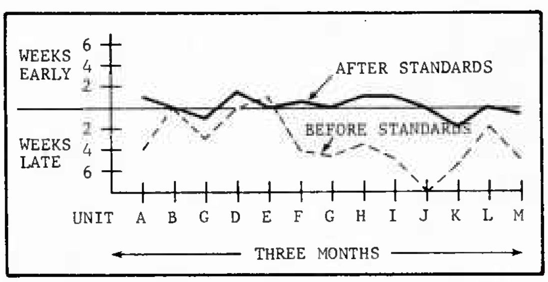

Figure 11. "After"

Engineered standards were developed for planning and scheduling purposes. In terms of schedule compliance, before engineered standards were used, work packages averaged over three weeks late with a maximum lateness of eight weeks. After engineered standards were used for planning and scheduling, average lateness was reduced to zero and maximum lateness was reduced from eight weeks to two weeks (Figure 11).

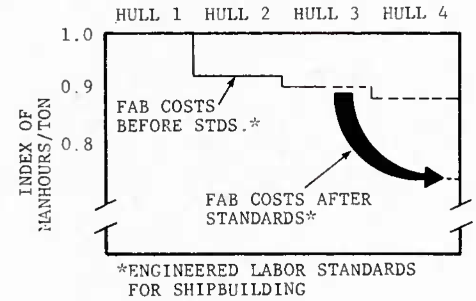

Figure 12. Projected Productivity Impact

Improvements in productivity attributable to the use of engineered standards were even more significant; with engineered standards only partially implemented in the fabrication shop, a reduction of 21% in the labor hours of the fabrication work packages was projected from the data collected (Figure 12).

The experimental results led to the following conclusions:

- Productivity improvements on the order of 20-30% can be expected.
- Schedule adherence is dramatically improved.
- Cost benefit analysis (Table 1) shows that including the one-time cost of establishing labor standards, there is still a 5-10% total reduction in fabrication costs; thereafter, cost reductions should range from 15-25%.
- The effect on follow-on operations is significant; by improving schedule adherence in the fabrication operation, performance of the next operation - panel sub-assembly - improved by being able to start most jobs on schedule.

Table 1. Calculated Payback

COST ELEMENT	HULL 1	HULL 2	HULL 3	HULL 4
1. STANDARDS DEVELOP.	$ --	$ --	$ 30	$ --
2. STANDARDS APPLICA.	--	--	22	--
3. PERFORMANCE DATA COLLECTION	--	--	11	11
4. COST OF STANDARDS	$ --	$ --	$ 63	$ 11
5. FAB COSTS w/o STDS.	$1,300	$1,210	$1,160	$1,120
6. PROJECTED FAB COSTS WITH STANDARDS			1,010	840
7. PROJECTED COST WITH STANDARDS (Including Cost of Standards)			1,073	851
	(Thousands of Dollars)			
PROJECTED NET SAVINGS	$ -0-	$ -0-	$ 87	$ 269

The results of this experiment were dramatic savings in fabrication costs, and improvements both in productivity and schedule adherence. As a direct result, the Manual on which this paper is based was then written to round out and complete the research effort that prompted the experiment.

SUMMARY

The main thrust of this Manual is improved planning and production control for shipyard use. Planning and production control exists as a support function to production, not as an end in itself. The aim is to orient planning for improved production through better application of resources, which has been termed production oriented planning. It is not a revolutionary idea, but rather an evolutionary one. It is something to work toward, rather than something that can be done immediately. Properly implemented and maintained, a planning and production control system is the one tool that can make the U.S. shipyards more efficient and economical than their foreign counterparts, for new construction or for repair and overhaul work.

This paper has not attempted to develop and justify many of the basic points made here. This backup information is, however, contained in the Manual itself, which is available from Bath Iron Works Corporation, 700 Washington Street, Bath, Maine 04530.

PRODUCTIVITY ASSURANCE IN SYSTEMS ACQUISITION

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ABSTRACT

The Productivity Assurance concept supports the national policy for productivity rate improvement and provides a methodology for its application in the weapon system acquisition process. The approach to Productivity Assurance was derived from the existing Quality Assurance concept. Its objective is to achieve greater efficiency in the use of resources through specific contractor business management. Productivity Assurance is intended to provide benefits to both the customer and the contractor.

In recent years, the United States has demonstrated one of the poorest rates of annual productivity improvement in the industrialized world. The impact of this factor is significant because it is a major contributor to the loss of foreign markets, inflation, and unemployment. For these reasons, as well as the shrinking DOD dollar and the movement of larger numbers of weapon systems from development to production, a concerted effort must be made to support the national goal for productivity rate improvement. However, most experts seem to agree only with the idea that productivity cannot be accurately defined or easily measured. Largely for these reasons acquisition agency and contractor attempts to manage productivity improvements usually result in confusion, frustration and ineffective actions and accomplishments.

Rather than attempting to formulate a definition for productivity which captures the complexities of its elements, it was decided to avoid that obstacle by approaching the problem in a more familiar way, which now also appears to be far more simple and logical. It was noted that the term productivity resembled the term quality with regard to the problem of accurate definition. The Productivity Assurance concept evolved from this analogy and the application of the same logic which resulted in the familiar Quality Assurance concept. Consequently, Productivity Assurance is defined as: a pattern of planned and systematic business management actions which provides confidence that the use of capital, technology, energy, and manpower resources will result in a system or equipment capable of being economically produced. It is specifically intended that Productivity Assurance be accomplished through the management efforts of development and production contractors in accordance with appropriate contract terms and conditions.

Commitments to achieve efficiencies of operations have their roots in those management principles and practices demanded by the competitive forces of the marketplace. However, in the environment of defense systems acquisition, conditions exist that have made the business practices of both the customer and the supplier considerably different from those found in the commercial marketplace. The type or degree of competitive forces that drive efficiencies of operations in commercial trade cannot be totally relied upon to provide the best products at the best prices for the often unique weapon system requirements. Therefore, the approach has been one in which, after requirements have been defined and properly communicated in the contract, various kinds of assurance are established during the life of that contract. Such assurances have long existed in the planning and control of design, quality and cost baselines. It is equally important that similar assurances be provided to make certain that resources are being optimally managed to enhance productivity.

It should be noted that the matter of productivity improvement or enhancement is not particularly new. For many years, the Air Force and other DOD agencies have emphasized individual programs designed or intended to encourage efficiencies, conserve resources, or reduce costs. But various problems associated with these programs actually worked to contravene the full realization of their expectations. Perhaps the greatest difficulty was in the way that they were perceived. They were precisely defined and specified to the point where management innovation and flexibility were stifled. The manner of implementation was piecemeal, causing each to be perceived as the ultimate cost control weapon and diverting attention from other equally important considera-

tions. These and other problems made such programs subject to wasteful dialogue and delays in implementation. Productivity Assurance provides a conceptual framework which eliminates many of these difficulties. It brings the matter of optimum management of resources sharply into focus; but at the same time recognizes that the means for achieving its objectives are limited only by the imagination and ability of management.

The Productivity Assurance concept provides a sound basis and objective for cost reduction initiatives. However, it is in the planning process where these objectives as well as the potential benefits are established. Productivity Assurance planning should encompass existing productivity-improving elements such as; Work Measurement, Methods and Process Analysis, Manufacturing Technology, Work Simplification, Value Engineering, Design to Cost, Capital Investment Strategy, Quality Circles, Job Enrichment, Producibility, Materials Engineering, Overhead Cost Analysis, Management Systems Analysis and Facilities Utilization. In addition, Productivity Assurance planning should address contractor organization, policies and procedures directed towards reducing hardware manufacturing cost. Quantitative and measurable internal management commitments must be a fundamental part of the plan.

Under this concept, it would be required that all major development and production phase contracts include a specific requirement for Productivity Assurance planning in the Statement of Work. Requests for Proposal would also include such a requirement. The adequacy of the plan submitted by offerors would then be evaluated and specifically utilized as a significant element in source selection. Subsequently, the plan submitted by the successful offeror would be updated and baselined at a formal Productivity Evaluation Review (PER) milestone to be conducted by the System Program Office Production/Manufacturing Manager early in the contract performance period. At the completion of the contract, a final PER will be conducted and the contractor's accomplishments will be measured against the objectives stated in his formal plan. The results will then be made available for use in connection with future solicitations to assist the Contracting Officer in evaluating that contractor's past performance.

In general, it is widely recognized that significant benefits will accrue from the process which results in improved productivity. The nation benefits from a better competitive position in the world market, helping to stablize our economy at home. The customer benefits by obtaining a needed product at lower cost. The employee benefits as self-fulfillment and job security are enhanced, and the quality of work life is improved. The company benefits as it becomes more competitive and profitable, with the expanded capability for greater investment and development of its human resources. All of these benefits are achievable within the present acquisition process through the application of the Productivity Assurance concept. For example, by using Productivity Assurance planning as a factor in source selection, those offerors who are already accomplishing this kind of formal planning would have a considerable competitive advantage. A further benefit might also be provided to contractors, in the form of a performance incentive or award fee, for ingenuity in productivity planning together with excellence in achieving stated objectives.

Productivity Assurance has been compared with Quality Assurance and like that program it unfortunately has some pitfalls. Perhaps the most serious is that related to false economy. The cost benefits which accrue from a sound productivity assurance program are hard to prove because they are initially subjective estimates or assessments based on early planning efforts. The preventive aspects of designing, developing and manufacturing a weapon system right the first time and avoiding costly mistakes will be among the least visible from a cost standpoint when compared with many other broad categories of costs. Pressures to reduce the total cost of a program often cause an examination of requirements to identify those which could be eliminated or reduced. This often results in a backlash effect which, in the long run only insures that costs will be higher. For example, the need for proofing programs for production processes and tooling might be overlooked in the stiff competition for the development dollar or preoccupation with system performance and schedules. The preventive aspects of productivity assurance, those actions which should be taken to forestall catastrophic and costly mistakes, require foresight and early planning and investment but become cost effective in the long run. In this regard, care must be exercised to avoid providing support to the premise that even though time or money is not available to do it right, the resources can be found to do it over.

Productivity Assurance is not intended to be a cost reduction panacea. Simply stated it is intended to provide an organized approach and visibility to a subject which all too often is assumed to be everybody's business and which just as often may become nobody's business. While many aspects of the present acquisition process itself may act as constraints to productivity improvement, the Productivity Assurance concept is not primarily intended to resolve such institutional matters. The concept assumes that there is considerable potential for improving the efficiency of resource utilization within the existing acquisition process. Achieving those benefits is the primary objective. Beyond this, the identification and resolution of any matter perceived to be a constraint, in the process of planning, negotiation dialogue or evaluation, would be an added benefit to both the customer and supplier. That potential also exists.

At the Air Force Electronic Systems Division,

elements of the Productivity Assurance concept are presently being utilized in several programs. In addition, an ESD Command Policy Regulation is being prepared which will require the use of Productivity Assurance planning in all major system program full scale development and production phase contracts. Experience has already indicated that the implementation of the Productivity Assurance concept will require the support and coordinated efforts of Program Managers, Manufacturing, Contracting and other concerned functional elements in the definition of tailored program requirements, source selection and evaluation criteria and contractual provisions and incentives. Such efforts, however, will yield far better results than piecemeal approaches to cost reduction.

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EFFECTIVENESS OF PROFIT NEGOTIATIONS IN THE PROMOTION OF CONTRACTOR EFFICIENCY

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ABSTRACT

As stated in the Defense Acquisition Regulation (DAR), "It is the policy of the Department of Defense to utilize Profit to stimulate efficient contract performance --- the aim of negotiation should be to employ the profit motive so as to impel effective contract performance." Effective performance is not necessarily efficient performance. Profit dollars should be negotiated in such a manner as to drive a firm to efficient as well as effective performance. Should cost analysis has given evidence of these inefficiencies but is not susceptible to being used for large numbers of acquisitions. Stable or narrow range negotiated profit rates will encourage cost inefficiencies. Negotiated profit rates will be reviewed for detailed analysis and interviews conducted with individuals involved with establishment of profit negotiation objectives. All data will be analyzed to determine if in fact there is a predetermined narrow profit range.

INTRODUCTION

Negotiated profit has long been considered a tool to be used in motivating a contractor towards accomplishment of the government's planned goals. The goals may be such things as achievement of performance characteristics, meeting delivery schedules, and/or control of costs to be incurred. As stated in the Defense Acquisition Regulation (DAR), "It is the policy of the Department of Defense to utilize profit to stimulate efficient contract performance --- the aim of negotiation should be to employ the profit motive so as to impel effective contract performance."(1) The objective should always to be encourage the contractor to obtain the most appropriate balance between effective and efficient performance.

PROBLEM

Effective performance can easily be measured as it is a necessary condition for satisfactorily meeting contractual requirements. Testing can be utilized to determine if the specification parameters are adequately met. Slippage of scheduled deliveries becomes an obvious departure from desired effectiveness of contract performance. However, inefficient performance is not so readily discerned. The contractor can deliver an entirely satisfactory item in adherence to the desired delivery schedule and have inefficiencies in his operation. Satisfactory physical performance is no assurance that cost effective performance is being obtained. If the final costs unreasonably exceed the negotiated costs there is an indication of inefficiency and/or poor cost estimating on the part of the negotiators. Even in this situation there is no clear evidence as to the degree of efficiency realized by the contractor in his contractual performance. Likewise, there is no assurance of efficient performance if the contractor's actual costs are very close to the negotiated costs. The negotiated costs could have included, unknowing to the negotiator, costs attributed to inefficiency.

Cost analysis should and often times does reveal inefficiencies in a contractor's operation. These inefficiencies are seldom eliminated by cost analysis. If they were, the application of should cost would not be so successful. In almost every should cost analysis there have been inefficiencies discovered that were not revealed by a regular cost analysis. However, should cost has two major drawbacks that preclude it from being the answer to the problem of measuring and obtaining efficiency from Defense contractors.

Should cost analysis requires the assembly of an integrated team of multi-disciplines to do an indepth cost analysis at the contractor's plant.(2) The team must consist of the highest caliber persons in their respective fields in order to conduct a truly effective should cost analysis. This requirement limits the number of teams that can be formed because of the scarcity and availability of such talent. The other limitation is time. The indepth should cost analysis is a time consuming process and cannot be effective when requirements are urgent or administrative leadtimes are short.

Stable or a narrow range of negotiated profit rates for Defense contracts encourage cost inefficiencies. This is especially true when the efficiency of a contractor's operation is not easily measurable. To demonstrate the verity of this one must consider the economic arena of sole source negotiated procurement.

Over 80% of the Army's procurement dollars were negotiated in the last two fiscal years and over 60% of these procurement dollars were negotiated on a non-competitive basis.(3) Assuming that competition is sufficient to motivate a contractor towards efficient operation, the other area that

may need adequate motivation toward efficiency would be the non-competitive acquisitions. In the research and development phase of acquisition the primary emphasis is usually on performance rather than cost. Therefore the real need to promote cost efficiency lies in the major non-competitive production acquisitions. This market arena is unique and has economic peculiarities found nowhere else.

A free enterprise economic system may be viewed theoretically as spectrum of market conditions ranging from perfect competition to perfect monopoly or monopsony. The extremes of this spectrum rarely exist and are only important in understanding the whole of an economic systems market. The area I plan to concentrate on will be the monopoly/monopsony portion of the spectrum.

It must be decided which portion of the spectrum most nearly coincides with the major non-competitive production acquisitions. The acquisitions falling within this parameter include one seller and one buyer which would indicate a bilateral monopoly (pure monopoly and pure monopsony).(4) However, in a pure bilateral monopoly the buyer has control of price and the seller has control of demand. This is not in reality the true market picture of the major non-competitive production acquisitions.

A monopolist's demand curve is a down slope and relatively inelastic, which case the buyer's demand will be relatively unresponsive to price changes.(5) This inelasticity of demand will allow the monopolist to set prices at a level that will gain the greatest possible revenue. On the other hand the monopsonist's demand curve is a horizontal slope and relatively elastic. The elastic demand would be extremely responsive to price. The bilateral monopoly situation is really an economic dichotomy and is one of many unsolved problems in economics.(6)

The market place of the major non-competitive production acquisitions more nearly fits the monopoly portion of the economic spectrum than any other. There is only one seller for whatever reason, whether due to large initial capital investment, technical know-how, inability to develop adequate detailed specifications. The demand is relatively inelastic and totally inelastic as far as the Principal Contracting Officer (PCO) is concerned. Quantities are programed long before they are actually procured. The program is approved and funded through the appropriations bills of Congress. The seller is well aware of the fixed demand long before the requirements are received by the PCO. The seller need only to project costs that approximate the amount of funds appropriated for that program. Lower costs are unlikely to cause much of a change in demand. Likewise higher costs would cause no shift in demand, a reduction of demand to coincide with the funds available, or in an extreme case where costs are prohibitive elimination of demand.

A monopolistic firm faced with relatively inelastic demand will price its goods at the highest price possible without reducing the demand. The higher the price, the more total sales for a given quantity and hopefully the more profit. A single buyer with a fixed demand will be at the mercy of the seller unless something other than demand can be used as a leverage against the seller. In the case of the government it can and will exercise sovereign rights such as the requirement placed upon the seller to divulge cost data and certify to its accuracy, completeness and currency.(7)

The government has also placed restrictions on the rate of profit that may be earned by a firm. (8) The demise of the Renegotiation Act and the Renegotiation Board has reinstated the applicability of the Vinson-Trammell Act of 1934. This Act as amended limits the rate of profit that may be earned by Defense contractors on Defense acquisitions of certain items. This paper will not deal with the details of such profit rate limitations but it is important to note that such limitations not only exist but are considered desirable by many people within the government as a way to preclude "excess profits" on Defense contracts.

The DOD profit policy recognizes that the automatic application of a predetermined percentage to the total estimated cost of a product, does not provide the motivation to accomplish or stimulate efficient performance.(9) A review of the history of DOD profit policy will show a consistent attempt to encourage flexibility in the negotiation of profit. However, it is believed that many people have a definite or narrow range of the percentage profit rate that is considered fair and reasonable. Negotiations outside of this range would be considered as excessive profit rates by government personnel or unacceptably low by Defense contractors. "It is tempting to decide this contractor or that contractor deserves a certain profit ---."(10)

Major non-competitive production acquisitions are believed to have three salient characteristics. The first is that the acquisition is conducted in a monopolistic situation. Second, the buyer cannot act as a monopsonist because of the relative inelastic demand. And third, the negotiated profit ranges are narrow and relatively fixed from one acquisition to another for the same item. These characteristics encourage inefficiency.

The buyer is naturally interested in making as much as the market will bear. Given a fixed demand coupled with a fairly constant negotiated profit rate the only way to increase sales and dollar profits for a given item would be to increase costs. The additional costs will be accompanied by a larger dollar figure of profit and increase total sales. The increased costs must be brought about by inefficiencies.

The elimination of narrow profit ranges will not of itself bring about efficiencies. Only negotiated profit rates that are tied into efficiencies effected by the contractor will truly en-

courage efficiency. This opinion is generally supported by economists and is even recognized as a factor by some economists that propose government control of profits on all businesses by setting upper profit rate limits.(11)

APPROACH

This study will examine Department of Defense profit policy promulgated in recent years to determine its impact on negotiated profit rates. Negotiated profit rate data on non-competitive acquisitions for fiscal years (FY) 1975 through 1979 will be obtained. Through the use of a multiphased sampling procedure selected contract pricing files will be reviewed for detailed analysis. It is anticipated that such an analysis will indicate that profit objectives are consistently in a narrow range for repetitive non-competitive production acquisitions. In these situations the contractors increase the profitability of their operation by increasing costs. A review of selected should cost analyses will be done to support this hypothesis.

Interviews will be conducted with individuals comprised of operations, staff, and other recognized pricing authorities. The interviews will give data on their profit philosophy and what they consider a reasonable profit rate. It is believed that these interviews will give insight into the unofficial policies followed in the development of profit objectives.

After all the data is gathered an analysis will be made to determine if in fact there is a predetermined narrow profit range in the negotiations of non-competitive production acquisitions. The analysis will also attempt to discern any impact the implementation of profit policy may have on a contractor's efficiency. It is anticipated that the analysis in this study will lead to recommended policies that would encourage performance efficiencies.

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ESTIMATION AND ANALYSIS OF NAVY SHIPBUILDING PROGRAM DISRUPTION COSTS

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ABSTRACT

Changes in ship design or specifications disrupt work on a ship, and can disrupt work throughout an entire shipyard. This increases costs. Additionally, government-directed changes may be the legal basis for claims when the contractor overruns cost and schedule for any reason. Outstanding claims for equitable adjustment based primarily on alleged delay and disruption due to Government changes reached the unprecedented level of $2.5 billion in 1978. Many within the Navy would like to move the disruption issue out of the courts by paying the full cost of changes as they are implemented. This paper reports a test of the feasibility of a statistical method for fully pricing shipbuilding change manhours.

INTRODUCTION

In the summer of 1978, the Navy settled most of the $2-1/2 billion in contractor claims outstanding against several shipbuilding programs. At that time, Assistant Secretary Hidalgo's office issued the "Shipbuilding Procurement Process Study," which makes several recommendations for reducing the potential for claims in future programs. One recommendation is that the Navy consider new contract clauses for handling the changes in ship specification and design that inevitably arise in the course of a shipbuilding project. Changes have been the focus of controversy in claims proceedings both because they provide the necessary legal basis for claims when the contractor overruns, and because their costs typically have been disputed. One method for handling changes is for the Navy and contractor to agree on a way to set a price for full payment of change costs that both sides accept as fair and binding. Such an agreement would make it clear how much changes cost the Navy and would provide a framework for deciding who is responsible for costs that are not paid under the basic contract. Of course, as the past controversies over claims testify, costing changes has always been a very difficult and inexact art. Current change pricing systems either do not provide for full costing, or involve complicated subjective judgments. We therefore consider using a statistical model to estimate the total costs of changes. A statistical model is potentially simple, objective, and (on average) accurate. In this study, we describe such a model and report the findings of our tests of the feasibility of using it to estimate the total cost of changes.

Our statistical model yields manhour cost estimates for changes, which consist of three components. The first, the hardcore cost, is the contractor estimate of the net cost in labor hours needed to accomplish the tasks specified by the change. Hardcore costs are audited and may be negotiated downward but they generally are not disputed. We use hardcore hours in this study as an indicator of the "size" of the change.

The second and third components are the direct and indirect disruption costs. Changes in ship design or specifications disrupt work on a ship, and can disrupt work throughout an entire ship yard. This increases costs, and we define disruption costs in general as the total of these added costs, above the hardcore costs.

The disruption costs that occur for a given workforce and work week are called direct disruption costs. Indirect disruption costs are the added costs that occur if the contractor responds to the change by adding workers or increasing overtime. We estimate direct and indirect disruption costs statistically. We then compute the total cost of a change as hardcore costs plus direct disruption costs plus indirect disruption costs.(1)

It should be noted that only costs that are statistically related to changes are included in direct and indirect disruption. Changes and disruption due to changes are only part of the reason why ships cost more than the contractor's bid. We also estimate the independent effect on efficiency of shipyard manning, labor turnover, and labor skills

This report summarizes our study and findings. We first describe the role of changes and disruption in past shipbuilding claims, and how our study supports recent efforts to avoid claims. The second section describes how we estimate the total cost of changes. Findings for our applications of the statistical cost model to the FF 1052 and DD 963 programs are reported in the third section. In the fourth section, we briefly outline how a change-pricing system based on a statistical cost equation could be put into practice. Conclusions follow.

Change Pricing and the Navy's Program to Reduce Claims

The shipbuilding claims problem has its roots in the progressive procurement policies of the mid-1960's. Under the leadership of Secretary MacNamara, the Department of Defense implemented procurement policies designed to increase suppliers' incentives to hold down costs. It became standard policy to use fixed price contracts or cost sharing contracts for all Naval shipbuilding. Another new policy was total package procurement which the Navy used for the Amphibious Helicopter Assault Ship (LHA) program and the Spruance Destroyer (DD 963) program. Total package procurement combined the responsiblity for design and production in one contract. In theory, these procurement policies limited the Navy's responsibility for cost growth. In practice, when the Navy made design and specification changes, it became potentially liable for cost overruns just as under a cost-plus contract. The difference was that under the new policies the contractor had to file a claim to get additional compensation. This is the fundamental reason why changes led to claims in the late 1960's and 1970's. Although changes as a percentage of total work were little different from the 1950's, claims became a substantial part of shipbuilding costs.

Of course, these policies alone are not sufficient to explain claims. Claims would not have occurred without overruns, and inflation combined with limited cost escalation coverage helped produce overruns. Changes also contributed to overruns, but more importantly, changes provided the necessary legal justification for claims. When contractors had overruns, they blamed these changes. The Navy countered that changes were only partly to blame. Negotiations frequently broke down, and as a result, virtually every shipbuilding program completed in this period resulted in a claim.

The "Navy Ship Procurement Process Study," issued by Assistant Secretary of the Navy (M,RA&L) Hidalgo was aimed at finding ways to avoid claims in future programs. Many of the study's recommendations would reverse the new policies of the 1960's, and return more of the responsibility for costs back to the Navy. Among other things, the study recommended cost-plus contracts for early ships in a program, more liberal escalation, and more cooperation between the Navy and shipbuilders in planning programs.

The Hidalgo initiatives should reduce the severity of claims. They do not eliminate changes or the potential for later claims against unpriced changes. The fee the contractor earns on cost-plus contracts will to some degree depend on how well he meets cost and schedule targets, so changes could lead to disputes over how targets should be adjusted when changes are made. Of course, the size of potential claims in fixed price programs is reduced by the more liberal escalation clauses, but the potential for a claim nonetheless continues to be high.

To reduce the risk of claims the Navy now wants to find a better way to handle changes within the context of the basic contract. One way of doing this is for the contractor and the Navy to agree on a method for pricing the full cost of changes. The Naval Sea Systems Command (NAVSEA) is currently evaluating full pricing plans that fix total disruption costs in relation to hard-core change hours. Using disruption "cost factors," program managers would periodically negotiate and pay the total cost of current changes. To be acceptable, however, such payments must be realistic and fair to both sides. Thus, successful full pricing requires a method for estimating the total cost of a change which is accurate and agreeable to the Navy and the contractor. If such a method can be devised, and full pricing instituted, the risk of claims can essentially be eliminated.

METHOD FOR ESTIMATING THE TOTAL COST OF CHANGES

The Navy is legally responsible for hardcore change and disruption costs under the doctrine of "equitable adjustment." However, there is no clearly established method of calculating the amount of the equitable adjustment. The problem is one of identifying all relevant costs.(2)

The hardcore costs of changes can be estimated using accepted industrial standards. These costs are associated with specific identifable tasks that are added or deleted by the change. However, disruption cannot be tied to specific change related tasks. Part of direct disruption costs result because changes may have a synergistic effect on efficiency over a number of ship systems, cost centers, or programs. Indirect disruption results because the contractor responds to changes by altering the schedule, workforce or the amount of overtime worked, which also has an effect which is not localized to a particular change. It would be impossible through established accounting procedures, to objectively identify these disruption costs with a specific change.

We estimate the total cost of changes by showing how the manhour cost of a ship varies as hardcore change hours are added. We first developed a model of shipbuilding and derived a statistical cost equation. The parameters of the equation were estimated using data collected for the variables in the equation. The coefficients of the equation show how each variable affects total manhour costs when all other variables are held constant. We use these estimated coefficients to calculate the total cost of changes. This work is described in detail in the remainder of this section.

The Model

Our theoretical analysis of the shipbuilding process identified the major variables that, in theory, explain the total manhour costs of a ship.(3) Shipbuilding is a very complex process, and the full range of variables that figure into the cost of a ship is very large. A general shipbuilding cost equation would require variables describing the ship, the shipyard, including other work, the work force, contract terms, Navy and shipyard management, and program changes and delays. An equation that incorporated all these variables would show what any kind of ship would cost in any shipyard. We focus on the more manageable task of explaining the total manhour cost of a given kind of ship in a given shipyard during a specific time period.

The theoretical analysis suggested that the following groups of variables should be included in the cost equation: (i) learning - which reflects productivity increases as more ships of one kind are built; (ii) a measure of the changes made to each ship; (iii) variables measuring work force productivity - such as yard or program manning, work force skills and experience, and the amount of overtime worked. We also consider the effects of (iv) delay; and (v) the manning level of other programs in the yard.

Changes and some of the other variables present difficult measurement problems. A change, for example, has many dimensions, including the number of hardcore manhours, hardcore material costs, the trades affected, the compartment or ship systems affected, and whether it is implemented early or late in the construction process. Conceptually, there is no problem in describing all the variables perfectly. There are practical limitations, however, and the equation will be more easily understood if the number of variables can be kept small. For example, we use only hardcore change hours to measure the size of a change. This undoubtedly limits our ability to precisely estimate how the cost of changes depends on variables such as those listed above. However, as we shall see, hardcore changes appear to serve very well to measure the effect of a change on total manhour costs. Using a limited number of variables, we are able to explain most of the variation in manhours across ships. In future applications, the number of explanatory variables could, of course, be expanded to obtain whatever level of detail is necessary.

The cost equation for our empirical analysis takes the general form shown in equation 1 below. The cost equation is applied to data measured for an interval of time. The average manhours used per unit of output in the period is the dependent variable. The right hand variables are either totals for the period (for example, total hardcore change hours) or are averages over the period (for example, the average number of workers, the average experience level of workers, and so forth):

$$\ln(MH/Q) = A + a\ln M + b\ln H + c\ln EX + d\ln SK + e\ln N + f\ln HC + g\ln MO + h\ln D + u \quad (1)$$

where: ln means "natural logarithm of"

- MH = manhours applied to a ship during a given period
- Q = output (physical completion of a ship during a given period)
- A = constant term
- M = number of workers
- H = average hours per work day
- EX = experience of work force
- SK = skill level of work force
- N = ship construction sequence (related to learning; the efficiency improvement for each subsequent ship)
- HC = hardcore change hours
- MO = manhours applied to other programs
- D = delay in ship delivery
- u = statistical error term
- a,b..,h = coefficients (manhour elasticities)

The coefficient of each variable shows how total manhours change for given output when the value of one variable changes, and all the other variables remain the same. For example, the coefficient of a skill variable shows how manhours would change if skill level increased while learning, changes, manning, experience, etc., are held constant. Thus, these coefficients show the quantitative relationship between manhours and each of the explanatory variables.

Calculating the Cost of Changes

The coefficient of hardcore change hours shows the percentage increase in total manhours for a one percent increase in hardcore change hours, when all the other right hand variables are held constant. Thus, this coefficient measures direct disruption costs.

To obtain a standardized unit for comparative purposes, we express direct disruption in terms of hours per hardcore change hour. We calculate this as follows: first, we compute from the change coefficient the implied increase in manhours for each hour of hardcore change work. Then, we subtract the hardcore hour from this total. For example, if the change coefficient indicates that total manhours go up by say 2-1/2 hours, one hour is hardcore, and the additional 1-1/2 hours is direct disruption.

The indirect cost of changes equals the costs due to increases in the work force, or overtime that are, in turn, due to changes. Our equations include these variables, so the costs of such adjustments are not included in the direct disruption cost. We must calculate these indirect disruption costs independently. To estimate the indirect cost of changes, we first have to estimate how changes affect manning, and overtime. We then calculate the effect of these variations on manhour costs. For example, if changes cause manning to increase by ten percent, the indirect disruption cost equals the estimated manhour cost associated with this increased manning. The sum of direct and indirect costs equals total disruption. The total unit cost of changes equals the sum of total disruption plus the hardcore cost.

EMPIRICAL ANALYSIS OF TWO SHIPBUILDING PROGRAMS

We applied the methodology outlined in the preceding section to the Avondale FF 1052 and Ingalls DD 963 shipbuilding programs to test our ability to explain manhours and estimate the manhour cost of changes. In this section, we describe our analysis of these programs and report the findings.

Our equations proved very successful in explaining the total manhours used for the ships in these programs. We were able to explain more than 90 percent of the variation in production manhours across data points in each program. When we broke the Ingalls data down into seven labor departments, we typically were able to explain between 60 and 70 percent of the variation.

Several versions of the statistical equation were estimated for each program. The findings were generally consistent across these different equations. Thus, we report a subset of findings, which are representative of what we discovered.

Our calculated unit costs of changes vary, depending on certain shipyard labor characteristics, and the magnitude of changes relative to total work on the ship. When calculated at the sample means of these variables, we estimate the unit cost of changes for all production labor to be about 3.5 hours for the FF 1052 program and 2.5 hours for the DD 963 program. For the DD 963 program the unit costs ranged from a low of 1.4 hours for the sheet metal department to a high of 4.4 hours for the paint department.

THE UNITS OF ANALYSIS
The units of analysis are described in table 1. The data are observed for 24 ships of the FF 1052 program. A total of 56 annual observations of 26 different ships are used for the DD 963 analysis. We analyzed seven labor departments individually as well as total operations manhours for the DD 963. The basic methodology is the same in both cases.(4)

VARIABLES
Our equations include as right-hand variables hardcore change hours along with manning, labor skills and experience, ship construction sequence number, and sometimes overtime and delay. The variables used in the analysis are listed in table 2.

We also considered interactions of changes with manning and turnover. Including these variables along with changes allows us to predict the effect of changes on manhours for different levels of manning or turnover.

It is important to emphasize that the unit of observation is not an individual change. We use the total hardcore hours for all the changes implemented in the observation period to explain the manhours in the period. However, over the many changes included in each observation, the individual differences tend to average out, and hardcore manhours are a good measure for the overall impact of changes.

Table 1. Units of analysis for the Avondale FF 1052 and Ingalls DD 963 programs

	Avondale FF 1052	Ingalls DD 963
Observational units:	Each ship.	Annual observation on each ship, fiscal years 1975 - 1978.
Sample size:	24 ships.	56 observations on 26 ships.
Manhour variables:	Total production manhours.	Manhours for: Total operations[a] Hull Manufact. services Pipe Outside machinists Sheet metal Paint Electrical

[a]Ingalls Total operations includes nearly the same crafts as Avondale Total production .

Table 2. Variables used to explain manhours

	Avondale FF 1052	Ingalls DD 963
Learning:	Ship construction sequence number	Ship construction sequence number
Manning:	Hull manning (equivalent men)	Yard operations and cost center labor (payroll) LHA program labor (equivalent men) Submarine overhaul labor (equivalent men)
Labor skills and experience:	Labor turnover rate (annual)	Journeymen/Total labor percentage Labor turnover rate (quarterly)
Overtime:		Overtime hours
Changes:	Negotiated change hours plus Navy claims team estimate of unnegotiated hardcore hours	Estimated production work added change hours
Delay:	Total delay in ship delivery	Change in estimated completion date during period (days)
Construction output:	The total ship	Manhours earned in period adjusted for changes in plan
Interaction variables:	Changes x turnover	Changes x manning Changes x turnover

FINDINGS

Our findings demonstrate the importance of learning, changes, manning and labor skills and experience in explaining manhours.

Estimates of the Regression Equations
The regression estimates for total production manhours for the FF 1052 and DD 963 programs are presented in table 3. Across from each explanatory variable is its coefficient (elasticity) estimated for each program. The elasticity of manhours with respect to a given variable is the percentage change in production hours that would result from a one percent increase in the explanatory variable with all other explanatory variables held constant.

Table 3. Findings for equations explaining total production manhours for FF 1052 and DD 963

Explanatory variable	Manhour elasticities FF 1052 program	DD 963 program
Learning	-.182	-.361
Changes	.285*	.053**
Yard manning		.439**
Hull manning	.248	
Manning x change interaction		.519
Yard turnover	.667*	
Turnover x change interaction	.953	
Submarine program		.407
LHA program		.184
Delay	.143	

*Computed at sample mean values of changes and turnover
**Computed at sample mean values of changes and manning

The FF 1052 Program. Our equation explained 99 percent of the variation in the natural logarithm of manhours used to build the 24 FF 1052's we observed. All of the variables were significant at the .95 level in explaining total manhours.

The learning coefficient shows that when the number of ships completed is doubled, the cost of the last ship in the second goup is 18 percent below the cost of the last ship in the first group. This translates into a learning rate of 88 percent.(5) Learning was actually better than the learning bid by Avondale.

Increased hull manning led to increased manhour requirements. Each one percent increase in hull manning is predicted to increase manhour requirements by about 1/4 of one percent.

We found that the coefficient for hardcore changes depends importantly on labor turnover. Changes are more costly when they are made during periods when turnover is high. The turnover hardcore change interaction coefficient of .953 implies that a one percent increase in turnover increases the manhour cost of a change by nearly one percent. The reported change and turnover coefficients are computed for the sample mean values of turnover and changes.

Delay was a very important determinant of manhours in the FF 1052 program. This is not surprising. This program was marked by many delays due to late delivery of plans, specifications, and equipment. The delay coefficient shows that every one percent increase in ship delay increases the manhour cost of the ship by .143 percent. This figure implies that a one month increase in delay increased manhour costs by 51 man months (8200 manhours). The positive and significant coefficient of delay suggests that delay was predominantly exogenous (bottleneck delay due to missing plans, specifications or equipment) rather than discretionary.

The DD 963 Program. Our equation explained about 94 percent of the variation in the natural logarithm of total operations manhours across the 56 observations on the DD program.

Manning dominated all other labor variables in explaining manhours in this program. This variable is a proxy for labor quality. As manning increased it became more difficult to hire the desired number of quality workers. The other labor variables (overtime, turnover, and the percent of the work force that were journeymen) were insignificant when the manning variable was included in the same equation. Thus, these variables are not included in table 3. These variables are highly correlated with manning, and although they are important determinants of manhour costs, the data do not allow us to sort out their independent effect on costs. Each of these variables is significant for total operations labor and some of the individual production departments when manning is excluded.

The estimated learning coefficient is -.361. This implies a learning rate of 78 percent when other factors are held constant. To an even greater extent than for the FF 1052, this estimated learning exceeds the learning incorporated in the original bid. Litton was not able to get its high- efficiency assembly line type production process into operation as quickly as planned. The LHA's also were in the yard longer than intended, which to some extent limited the availability of facilities and forced the use of more workers in the yard than intended. This learnng therefore partly reflects the breaking in of the new yard, a move to the planned production process, and diminishing influence of the LHA.

We found a significant interaction effect between hardcore change hours and yard manning. The coefficient implies that a one percent increase in manning increases the cost of changes by .519 percent. The coefficients of manning and changes shown in table 3 are computed at the sample mean values of changes and manning.

Yard manning, submarine program manning, and LHA program manning must be interpreted together. These three variables represent two interdependent effects. One is the effect of total yard manning on productivity. The other is the effect of programs competing for facilities and labor quantity and quality.

When total yard manning goes up, holding submarine and LHA manning constant, the added workers by definition go to the DD 963 program. Thus, the yard manning coefficient shows that a one percent increase in DD 963 manning, holding the other programs constant, increases manhour requirements by .439 percent.

The submarine and LHA variables show the effect of adding men to these programs while holding total yard manning constant. Both effects are positive. A one percent increase in submarine workers at the expense of the DD 963 program increases DD manhour requirements by .407 percent. A one percent increase in LHA workers increases DD manhour requirements by .184 percent.

Since yard overmanning due to the delay of the LHA is considered a major factor in Ingalls' production problems, we expected the manning of the LHA to be a significant variable in explaining DD 963 manhours. The significance of the submarine program variable is somewhat surprising. The submarine work is physically separated from the other programs, and the submarines never accounted for more than eight percent of the yard's operations labor work force. However, some observers conjecture that the submarines were sometimes given the most highly skilled workers at the expense of the other programs. In addition, the time pressures of the overhaul work might also have diverted a disproportionate amount of management attention to this work.

The DD 963 Program by Labor Department. Table 4 summarizes the qualitative findings for seven Ingalls production departments. We report the same basic specification as used for the overall analysis. This includes the manning-change interaction term as well as any additional variables that are significant. Across from each variable are the findings for each of the seven departments, which are listed across the top. With the exception of delay and ship sequence number, all of the variables are measured separately for each of the labor departments. A plus sign or minus sign shows the direction of effect when the variable is significant in explaining department manhours. A blank indicates the variable was not significant for the base case estimates.

Learning is the only variable that is significant across all departments. The hardcore change hours variable is significant for all departments but one. Either the turnover-change or manning-change interaction variable was significant in every case. These qualitative findings are consistent with the findings for total operations manhours.

Considerable differences exist among the labor departments. This is readily apparent from our qualitative findings.

The yard manning variables show the effect of building up manning of the DD 963 program while holding constant the manning levels of the other two programs. This means manhours fell (efficiency rose) as more men were added to the hull, outside machinist, paint, and sheet metal departments. We conclude that these departments were generally manned below their optimum levels so that efficiency rose as manning increased. This is consistent with the manning history for these crafts.

In the basic specification, turnover is significant for three departments (outside machinist, paint, and sheet metal). Three departments (pipe, paint and electrical) have significant turnover-change interaction effects when this variable is entered in place of the manning-change interaction. Pipe, machinists, and electrical typically require highly skilled workers which were chronically in short supply. This could explain why turnover is more of a problem for those departments.

The percent journeymen and overtime variables were significant in a few cases. However, the percent journeymen variable was never significant when entered with yard manning. For most departments, this variable closely followed yard manning; when the yard was building up, journeymen fell as a share of the total work force. Thus, we can't distinguish the effect of this variable from the effect of yard manning.

Overtime was significant in two departments. It was anticipated that overtime increases manhour costs. This was the finding for the hull department. However, we find manhour requirements were reduced by using overtime in manufacturing services. The manufacturing services department performs support functions for the other departments and includes carpenters and launch pontoon personnel. These workers play a key role in events such as launch where timing is critical. One interpretation consistent with our findings is that schedule adherence and proper sequence are particularly important contributors to efficiency for manufacturing services. Thus, the use of overtime is an efficient use of manhours.

The delay variable did not significantly add to our ability to explain total operations manhours. We find, however, that delay is significant in two labor departments. Sheet metal department manhour requirements were greater the longer was delay, but pipe department manhour requirements were lower. This pattern of results supports the report of many observers that the pipe department was the most critical craft. The negative delay coefficient indicates that the original ship delivery schedule required the pipe department to work at a faster than efficient rate. Thus, efficiency rose when a ship was delayed.

Table 4. Qualitative findings for equations explaining manhours for major Ingalls labor departments

EXPLANATORY VARIABLES	INGALLS' LABOR DEPARTMENTS: HULL	MFG. SERVICES	PIPE[a]	OUTSIDE MACH.	PAINT[a]	SHEET METAL[a]	ELECTRIC
LEARNING	–	–	–	–	–	–	–
CHANGES	+	+	+		+	+	+
YARD MANNING	–	+		–	–	–	+
MANNING - CHANGE INTERACTION	+	+			+	+	+
TURNOVER				+	+	+	
OVERTIME	+	–					
SUBMARINE PROGRAM			+	+	+		
LHA PROGRAM	+						+
DELAY			–			+	

[a]The manning-change estimates represent the base case, and all the findings in the table apply to that case. However, for these shops the turnover-change interaction is significant, and yields greater explanatory power than the base equation.

<u>The Manhour Cost of Changes</u>

In this section we use the estimated coefficients of the cost equations to estimate tht total cost of changes. We also examine the sensitivity of the cost of changes to varying levels of manning and turnover.

<u>The FF 1052 Program</u>. The direct disruption cost is sensitive to the level of turnover. Direct disruption varies between .81 and 2.67 when turnover is varied 10% below and 10% above the mean value of 60%. At the mean of turnover, direct disruption is 1.78 hours per hardcore change hour.

Some delay was caused by changes and is therefore related directly to hardcore changes. To identify the indirect disruption cost of delay due to changes, we estimated the equation shown in

table 3 but with delay omitted. Using this estimate of the change elasticity we calculated the indirect disruption cost of delay as .5 manhours per hardcore change hour.

Omitting manning from the estimating equation resulted in a serious misspecification so we estimated the indirect effect of this variable differently. On average, change hours accounted for 10-1/4 percent of total hours. These additional hours could have been put in partly by hiring more workers and partly by delaying the program. We assume that 10 percent more men were hired. Turnover was not positively related to ship manning for this program so we assume turnover was not affected.

Our findings for manning imply that a 10 percent increase in manning increases total manhour costs by about 2-1/2 percent. This is roughly 1/4 hour of indirect disruption for each hour of hardcore change work.

The total cost of one hardcore hour of change is shown in table 5.

Table 5. Estimated total cost of one hardcore hour of change for the FF 1052 program at mean values

1.00	Hardcore change hour
1.78	Direct disruption costs
.50	Indirect cost of delays due to changes
.25	Indirect cost of 10 percent added ship manning
3.53	TOTAL

Table 5 shows that total disruption equals 2.5 hours per hardcore change hour.

The DD 963 Program. For total operations, direct disruption is 2.48-1=1.48 manhours per hardcore hour of change work. This estimate is sensitive to variations in yard manning. Estimated direct disruption is only .36 hours when manning is 10 percent below average. Direct disruption is 2.62 when manning is 10 percent above average.

The direct disruption costs of changes varies considerably among labor departments. Four departments are below the direct disruption cost for total operations. The sum of hardcore and direct disruption costs for these departments are 1.05 manhours for sheetmetal, 1.75 manhours for the hull department, 1.94 for outside machinists, and 2.26 manhours for manufacturing services, when calculated at the mean manning level for each department.

For the three labor departments employing the most highly skilled crafts - pipe, machinists, and electrical - the sum of hardcore and direct disruption costs ranged from just under 2 hours to nearly 4 hours. The highest cost of 4.36 manhours was for the paint department, which accounted for only a few hours for each change. Thus, paint direct disruption was small in absolute terms, but large relative to the small number of hardcore change hours.

The sensitivity of direct disruption to variations in manning also differed among the crafts. Pipe and sheetmetal costs were not very sensitive. A hypothetical variation in manning of ± 10% led to less than 1/4 hour variation for pipe and the variation was negligible for sheetmetal. The costs of the manufacturing services department was most sensitive to manning variations. The sum of hardcore and direct disruption costs actually fall below one, implying negative disruption, when manning drops 10 percent below average for this department. This can be explained by the small variation in manning for this craft. The 10% change in the natural logarithm is 14.5 standard deviations from the mean. We are therefore examining this variable at a point well outside its normal range.

These findings show that there is a great deal of variation among the departments. However, the pattern of the findings is consistent with the expected relative magnitudes of direct disruption costs for the various departments. The pipe, paint and electrical departments, crafts which are expected to be more susceptible to disruption because of the nature of their work, have greater estimated direct disruption costs.

The paint cost center shows the highest direct disruption cost. This finding is consistent with a craft which requires a lot of set up time for the amount of work done on each change. Additionally, change work for painters is frequently brush work, as opposed to original work where an entire compartment can be prepared and sprayed.

The indirect disruption costs of changes are small for this program. There are several reasons for this. First, DD 963 program changes represent

a small fraction of the total work in the Litton yard, so workforce adjustments due to changes were minimal. In addition, our findings for several departments indicate that manning was limited by the supply of workers, making adjustment for changes infeasible. Second, delay or overtime are significant in the cost equation for only four crafts. The variables were not in the equation explaining total operations manhours, so the costs of delay and overtime related to changes are already included in the change variable coefficient.

Net DD 963 hardcore change hours amount to only about 2 percent of the total manhours used to build each ship. If we were to suppose that DD manning increased 2 percent in response to changes, the implied indirect effect of manning would be .22 manhours per hardcore hour of change work. However, examination of the data indicates that manning did not respond positively to changes. We therefore believe that this indirect effect was negligible.

Manning coefficients were negative for the hull, outside machinist, paint and sheet metal departments. This implies that the net effect of a labor force buildup due to changes would be to reduce manhours. The available evidence indicates that these negative coefficients reflect Ingalls' difficulties in hiring and retaining workers at some times in the program. Thus, the size of the workforce was determined mainly by hiring and retention problems, and did not respond to changes.

Overtime was significant for two labor departments (hull and manufacturing services). However, the correlations between overtime and changes are negative and small for these crafts. Thus, we conclude that although overtime is significant, there were no appreciable overtime costs due to changes for these crafts. This is in agreement with the fact that the contractor generally did not include additional overtime in his change proposal estimates.

Delay was not a significant variable in the equation explaining total hours. Delay was closely correlated with changes. Thus, any delay costs are included directly in the costs of changes. Delay was significant for the pipe and sheet metal departments. Table 6 presents the calculations of the indirect delay costs of changes for these two departments. We found that delay reduces costs for the pipe department, so it is not surprising to find that delays attributed to changes also reduce costs. Thus, the indirect unit cost of delay is negative.

The sheet metal costs are positive, and about the same magnitude.

Table 6. The indirect costs of delay in the DD 963 program (pipe and sheetmetal departments)

Department	Unit cost without controlling for delay	Unit cost controlling for delay	Difference
Pipe	3.18	3.51	-.33
Sheet metal	1.39	1.05	+.34

Indirect disruption costs for the DD 963 are small in all but one case. This is consistent with a program where hardcore change hours were a small percentage of total manhours.

The total cost of changes is shown in table 7. Inclusion of the indirect effect of manning and overtime would require assumptions which do not appear to be warranted by our findings. There fore, the total unit cost of changes is essentially the same as the direct unit cost.

These are our best estimate of the cost of changes for the DD 963 program for the four fiscal years 1975-1978. We believe they are representative of the actual cost of changes for that program in the time period analyzed.

A SYSTEM FOR PRICING CHANGES

The estimation results summarized in the preceding section show that it is practical to estimate the total cost of changes using a statistical cost equation. We believe the estimates of total change costs derived from this equation are sufficiently accurate to serve as the basis of a change pricing system. Work remains, however, before such a system could be put into use. In this section, we discuss some of the issues that need to be resolved in developing a practicable change pricing system based on a statistical cost estimating equation.

Implementation of the system to price changes requires three basic steps: (i) At the outset of the program, the Navy and the contractor must agree on the equation to be used; (ii) periodically, say every three months, the

Table 7. Estimated total cost of changes for the DD 963 program (fiscal years 1975-1978)

	Total production	Hull	Mfg. services	Pipe	Outside machinists	Paint	Sheet metal	Electric
Hardcore hour	1	1	1	1	1	1	1	1
Direct disruption cost	1.48	.75	1.26	2.51	.94	3.36	.05	2.93
Indirect disruption cost of delay				-.39			.34	
TOTAL COST for each hour of hardcore change work	2.48	1.75	2.26	3.12	1.94	4.36	1.39	3.93

equation would be estimated and the total cost of changes for the program calculated; and (iii) these cost estimates would be used to price changes for the following three-month period.

The test applications reported here used data from the DD 963 and FF 1052 programs that were collected for other purposes. The cost equation could be much more detailed in future applications. For example, our analysis of the DD 963 program shows that the equation can be applied for each labor department. However, the Ingalls Shipyard further breaks down accounting data by work area and ship system. If these data were used, the statistical cost equation could be applied for each labor department further broken down by work area, and/or ship system. In addition, this could make it feasible to include more detailed characteristics of changes and other variables. We believe a cost equation will be more accurate, and the resulting change pricing system more flexible, the more detailed we make it. But it is also more costly. Thus, one important issue that must be resolved is the required level of detail. Further experience will be necessary to determine the most cost effective level of analysis.

Another issue relates to how the statistical estimates of the total cost of changes will be used in pricing changes. The most straightforward approach is to use the estimates of the model to cost a change, and agree that this is the price that will be paid.

Alternatively, a more complex system could be devised in which the estimated change cost serves as a baseline, and the price to be paid negotiated from there. However, if such a system is adopted, some limitation must be placed on the range for negotiations; otherwise these negotiations could break down just as change pricing negotiations have broken down in the past.

The questions of whether the change price arrived at by such a system should be a fixed price, or have a cost sharing provision should also be resolved. Cost sharing, with a maximum price, would seem to be a good way to share the cost risk of a change while still limiting the Navy's total liability for the change.

The cost equation is designed to measure the contractor's actual cost of performing change work. It is Navy policy to provide equitable payment for changes. However, any system for pricing changes including the one outlined here must address incentives to increase the price above that which is equitable. First, of course, a system such as this limits the contractor's incentives to hold costs down, because if the contractor is inefficient in performing change work these inefficiencies will become embodied in the prices paid for changes. The second problem is that a system such as this gives the contractor incentives to negotiate higher hardcore costs than might be warranted. On the whole, we do not believe these problems are worse for this system than for other proposed methods for pricing changes, or for the systems used to handle changes today. Contractors always have an incentive to overstate the cost of changes, and the current system does not safeguard the Navy against contractor inefficiency.

In addition to the current system for auditing and negotiating hardcore costs, a statistical change pricing system would provide information about inefficiencies not associated with change as a further safeguard against overpayment.

These issues will best be resolved with practical experience in using a change pricing system. We believe the best way to gain this experience is by further experimentation with the system using data from an ongoing program.

CONCLUSIONS

Our analysis of the two programs show that:

(i) Actual learning exceeded bid learning in both programs. For the FF 1052 program actual learning when other sources of inefficiency are controlled for was only slightly better than bid. The very steep learning curves for the DD 963 program reflect substantial start up costs as the new yard was being broken in.

(ii) Changes affect production manhours significantly. Total disruption was 2.5 hours per hardcore change hour for the FF 1052 program and 1.5 hours per hardcore change hour for the DD 963 program.

(iii) Increased manning and labor turnover increase production manhours significantly.

(iv) The cost of changes depends on the values of these manpower variables

(v) Delay significantly affects production manhours independently of changes in the FF 1052 program, but not in the DD 963 program. This reflects the importance of bottleneck delay due to missing plans, specifications and equipment for the FF 1052. For the DD 963 delay was primarily decision delay and was highly correlated with changes.

(vi) Competing programs (LHA and submarine overhauls) had a measurable impact on DD 963 operations labor. This was also true for five of the seven individual departments.

These findings confirm what is generally believed to be the primary determinants of the costs of building a ship in a given shipyard. More than this, the regression estimates show the quantitative effects of the explanatory varibles in these two programs to be in good agreement with both theory and intuition.

We have shown the feasibility of allocating inefficiency to changes and to factors for which the contractor is generally considered responsible. This was done using the available data from historical shipbuilding programs. These statistical methods could be applied with even more precision and confidence using data gathering systems designed explicitly for estimating change costs. Thus, we believe this methodology holds considerable promise for fully pricing changes in future shipbuilding programs.

FOOTNOTES

(1)Note that direct and indirect disruption costs do not correspond to the classification most often used in the literature. Total disruption is generally defined as equal to local disruption plus program disruption. Our definition of direct disruption includes all change costs that are not due to adjustments in work hours or the work force; therefore, direct disruption includes more than just local disruption. However, in the absence of any error the sum of direct and indirect is the same as the sum of local and program disruption.

(2)In recent cases the courts have ruled that the contractor is entitled to "being made whole". This implies that he is entitled to the recovery of reasonable costs based on his position as a result of the change and his industrial practices. This is in contrast to the criterion of "fair market value" which implies payment commensurate with the industry costs at large. At the same time the contractor is obliged to mitigate against unreasonable costs such as failure to obtain the best available price for material.

(3)A full description of the theoretical model is available from the authors.

(4)Avondale FF 1052 program data covered the total construction period. Data limitations restricted analysis of the DD 963 to four years (July 1974-July 1978). Consequently, our findings for the latter program apply only to this four year time period.

(5)The learning coefficient is the percentage decrease in marginal cost for a one percent increase in the number of units. Learning rate is the cumulative average cost of 2x units expressed as a percentage of the average cost of x units. Note that the greater the learning rate the lower the efficiency gains for subsequent units.

ECONOMIC PRICE ADJUSTMENT PROVISIONS IN GOVERNMENT CONTRACTING AND SUGGESTED ALTERNATIVES

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ABSTRACT

There are alternatives to the traditional Economic Price Adjustment (EPA) provisions in Government contracting. These include bands, thresholds or plateaus, abnormal escalation methods with projected indexes and high/low bands, sharing arrangements, and adjustments computed on the lesser of Bureau of Labor statistics indices or contractor actual rates. A detailed examination of several most commonly used Producer Price Indexes (PPI) and Standard Industrial Classification Codes (SIC) from January 1974 to January 1980 indicates a continuing escalation trend but with slight fluctuations, in most cases almost straight line increases. The ability to forward price in lieu of escalation provisions is quite evident. There are some recently developed mathematical models for forecasting EPA commitment requirements after contract award, not organizationally unique and which can be applied to projections of EPA requirements prior to contract award, thus reducing requirements for EPA provisions. Continued use of escalation provisions without careful consideration does not encourage contractors to apply efficient effective management tools to minimize the effects of inflation.

For us in Government procurement, the threat and effects of inflation present a very significant problem in our ability to contract for equipment and services. Contractors are extremely reluctant to forward price for delivery of items without some guarantee against the possible effects of unforeseen inflationary increases.

Prior to the early 1970's, forward pricing had been the preferred method in Government procurement to achieve competition and secure the lowest possible price. Forward pricing is that pricing of those economic trends that can be determined with a reasonable degree of confidence. Increased use of forward pricing had accelerated due to the emphasis for use of fixed price pricing arrangements which carried long contractual periods of performance. With the advent of the oil embargo and other material shortages in the fall of 1973, the Government found that a very limited number of contracts contained EPA provisions. The resulting spiraling inflation triggered by the oil embargo, necessitated contractors to absorb large cost increases on FFP contracts, subsequently resulting in substantial increases in requests for relief under Public Law 85-804. What began to occur in the fall of 1973 left PCO's with no choice but to enforce terms of contracts, because of the absence of a legal basis to provide contractual relief. In a dynamic economy like that of the United States where items fluctuate widely in price, it became apparent that EPA provisions were required which would protect both the Government and the contractor. Studies had been conducted by the Logistics Management Institute and the 1969 ASPR Committee on Wage and Material Price Escalation which provided several recommendations to alleviate the problem of contracting in an inflationary period. These studies ultimately resulted in the adoption of Defense Procurement Circular No. 120 issued March 1974. This DPC introduced a new clause - the Cost Index method. A synopsis of current basic EPA clauses is noted on the following Table I. A ceiling of 10 percent is currently imposed on each of the clauses.

Table I
Current DAR EPA Provisions

7-106.1	Basic Steel, Aluminum, Brass, Bronze, or Copper Mill Products
7-106.2	Nonstandard Steel
7-106.3	Standard Supplies
7-106.4	Semistandard Supplies
7-107	Labor and Material - Actual Costs
3-404.3(c)(3)	Labor and Material - Cost Index

Ceilings on maximum price adjustments under EPA provisions or the lack thereof is a subject of much debate in the acquisition community. Proponents of no ceilings contend that unlimited upward adjustments are equitable since the Government has the right to unlimited downward adjustments. They contend that the absence of a ceiling is the only way to protect contractors from unforeseeable significant economic fluctuations in labor and material. However, proponents of ceilings on EPA adjustments contend that it is the only method of placing a figure on the maximum liability to the Government. A ceiling also encourages efficiency on the part of the contractor whereas no ceiling can encourage inefficiency. The lack of a ceiling can cause a contractor to inefficiently purchase materials and place subcontracts.

Additionally the contactor has no incentive to make the best use of the types of skills in his work force. All types of contracts should have a maximum Government liability feature. An EPA provision with a ceiling contains this essential feature of a Government contract. The percentage of base unit price subject to EPA adjustment is just as controversial as ceilings. Those espousing 100 percent coverage maintain that it permits the contractor to stay in the same relative position, price-wise, as at the time of award. Profit is as necessary to a contractor as any cost element. Proponents of all costs being subject to the EPA provision argue that indirect costs fluctuate in the same manner as direct costs. There is labor in both direct and indirect costs. For instance, if direct or union labor receive a pay raise, foremen and other supervisory personnel who are usually indirect charges, receive comparable wage increases.

President Carter, in his concern over increasing inflation, issued a memorandum on 18 May 1978 that espoused the principle of deceleration. This principle is based on decreasing the rate of inflation in an increasing manner and shifting a portion of the potential price increases to contractors. Subsequent guidance issued by the Office of Federal Procurement Policy in October 1978 directed procuring activities to encourage pricing of contracts on a basis that includes and considers all costs which can reasonably be expected to be incurred during the period of performance. Thus, we have come full circle to a position of forward pricing as was being utilized prior to the adoption of the 1974 ASPR EPA clauses.

There are alternatives to the traditional or basic approach of handling escalation offered by the basic DAR clauses. There are three variations of contractual arrangements that may be used in measuring fluctuations of indexes. The Constant Dollar Method is commonly used whereby a base index is established for labor and materials and adjustments to cost and/or price are made from that index. This is the basic or accustomed approach. In the Projected Index Method we price on the basis of a normal trend for inflation, establish a single index for each adjustment period, and provide adjustments for variations between the actual index for each period and the projected index for that same period. The Normalcy Band Method is sometimes referred to as the "abnormal escalation" method. An index is first estimated as in the projected method. Then a high/low band is constructed around the projected index. Adjustments are made when the actual index is either above or below the high or low index. Here again, the contractor includes a normal amount of inflation in his proposal.

Utilization of a band, threshold, or plateau similar to the normalcy band method is another alternative. Escalation will only be paid on the amount by which the incurred escalation exceeds the band. The primary purpose of the plateau is for application to competitive procurements. This forces contractors to be more competitive in initial pricing and serves to pass a share of the inflation risk to the contractor. The band also eliminates small cost adjustments which involve higher administrative costs of preparing and granting the adjustment than the amount of the adjustment warrants.

Another modified cost index method EPA provision may be considered which is based on the lesser of adjustments computed based on BLS indices and contractor actual rates. An example is shown in Table II.

The offer selects the BLS classification code or codes to be used as an independent measure of cost fluctuations and supports them. The offeror projects to the midpoint of each computation period, the code selected which is the Estimated Labor Index (ELI). The Estimated Contractor Labor Rate (ECL) is computed similar to the ELI using the same base index period. Actuals are computed for the index and actual rate incurred. The contractor is then reimbursed for the lesser of the two calculated adjustments on a cumulative basis.

Contract modifications, changes, new work, deletions, and stretchouts present unique problems with regard to the use of an escalation provision. When a contractor prices a modification to the contract, he usually uses his latest forecast of labor rates, overhead rates, and the most recent quotes for materials. If these amounts are then added to the expenditure profile established for the basic contract and the indexes used in the clause are not changed, then it is possible for a double adjustment for inflation to be made. Deletions could, in turn, result in an understatement of subsequent economic adjustments unless deletions were made on the basis of original pricing. An equitable way of including contract modifications is to have all changes priced at the same labor rates that existed at the time of the pricing of the basic contract and deflate material costs back to the basic contract time frame. Normally, modifications are not of significant value and do not cover long time periods, therefore, do not need to be covered by EPA provisions. When modifications are significant and cover long time periods with economic uncertainties, then a separate table of indexes and expenditure profiles can be added to the existing EPA clause. This will allow the pricing of the modification with current pricing data. Stretch-outs present a problem unto themselves because they usually involve a combination of deleting effort during the early years and adding effort in the later years. There is always a question as to whether to price out the deleted effort at the rates it was originally priced at or the current forecasted rates; and for the added effort, whether that should be priced at original contract rates or current forecasted rates. Preferably, as in the case of changes, stretch-outs should be priced at basic contract rates and materials deflated to the basic contract time frame if this effort is to be included in the economic price adjustment clause.

When there is uncertainty in estimating costs due to economic conditions, other forms of contractual coverage can be used. The most desirable for the seller would be a cost reimbursement contract, however, that would provide for all contingencies

and does not afford the customer with the legal and financial protection inherent in a fixed price type contract. A compromise is to have a cost reimbursement line item or a savings clause for the questionable items in conjunction with a fixed price type contract. Most common of pricing problems is obtaining realistic and timely estimates from subcontractors. Consider a savings provision which lists the subcontracts and amounts included in the negotiated cost/price, and provides for an adjustment based on the amounts negotiated between the prime and subcontractor. The adjustment could be limited to specified amounts, downward only, with or without profit, and/or include a cost incentive provision.

An analysis was made of actual Selected Producer Price Indexes and Standard Industrial Labor Classification Codes for 20 codes utilized frequently by the Army Armament Material Readiness Command and which most correctly represent the predominance of those items procured by that command. This analysis covered the period January 1974 to January 1980. The plotting of those actual indexes indicates a continuing picture of rising inflation throughout that period. However, discounting minor fluctuations, these plotted data indicate an almost straight line increase throughout the period. I submit that the availability of these data to both Government and contractors should permit both parties to forward price without a great degree of difficulty for most commodities, with considerations allowed for known predictable events. The utilization of an EPA provision may not be necessary in many contractual arrangements.

Table II
Computation of Direct Labor EPA
Lower of Cum Period Variance or Contractor Plant Wide Rates

Comp Period	Expend Profile	ELI	ALI	Period Var	Cum Var	ECL	ACL	Period Var	Cum Var	Cum Adjust
1	10,000	5.00	5.00	10% or $1,000	1,000	6.00	6.24	4% or 400	400	400
2	10,000	5.50	5.75	4.5% or $450	1,450	6.60	7.00	6% or 600	600	1,000
3	10,000	6.00	6.24	4.0% or $400	1,850	7.00	8.40	20% or 2,000	2,600	1,850

ELI - Estimated BLS Index
ALI - Actual Labor Index
ECL - Estimated Contractor Labor Rate
ACL - Actual Contractor Labor Rate

As is evidenced by the preceding illustrations, we have a variety of means for dealing with the problem of forecasting for escalation in Government contracting. We have developed a myriad of clauses and alternatives seemingly to protect both Government and contractor from <u>unusual</u> fluctuations in market prices of required materials or unforeseen significant labor increases. The principle of fixed price contracting is a sharing of risk. Continued use of full reimbursement of escalation does not encourage the contractor to apply <u>efficient effective</u> management tools to minimize the effects of escalation, thus the Government continues to reimburse contractors for full escalation without an equal share of the risk being borne by those contractors. Contractors are normally expected to manage and control their total costs during performance of a contract regardless of the causes for cost fluctuation.

I submit that, although we are continuing in a period of escalating prices, the degree and effect of escalation is now more predictable than that experienced in the early 1970's. I believe that contractors have a greater ability to forward price than we give them credit for. I also believe that we tend to provide for escalation simply because a vehicle--the clause--is available. We must analyze each situation carefully to determine if escalation provisions are really necessary. The principle of fixed price contracting and an equitable sharing of the risk is disappearing.

Finally, there are some existing proven models for forecasting commitment requirements for EPA after contract award. I suggest that perhaps these models may also be utilized in the forecasting of anticipated escalation prior to contract award, thus forward pricing.

Early in 1978, funding problems were encountered on two offshore procurements entered into by ARRCOM. Analysis of these problems highlighted two basic problem areas. First, the contracts required payment in a foreign currency, and the rapid on-going deterioration of the dollar exceeded the anticipated expenditure rates. Secondly, both contracts contained an EPA clause which was linked to measures of the respective foreign economies. These measures were increasing at a rate which exceeded estimates provided for this type of cost growth. When the funding problems on the two foreign procurements were resolved, it was decided that effort would be expended to determine whether similar funding problems were occurring due to EPA clauses in domestic contracts. The study examined current methods of determining the level of EPA funds to be reserved or committed after contract award and

developed several methods for estimating this requirement. The primary approach was based upon the use of simple mathematical models. The study results successfully demonstrated the excellent potential for providing significant reductions in the amount of EPA to be reserved. The results of the study were based upon an initial "static" test in addition to a follow-on "dynamic" test. From the "static" test, it was determined that approximately \$100,000 per contract could be released from the EPA committed category for use elsewhere. The "dynamic" test included an initial projection, plus two quarterly updates, for 29 contracts. Four of these contracts used the cost index method, and the remaining 25 the actual cost method. Use of the appropriate developed model significantly reduced EPA contingency fund requirements by an average of \$270,000 per contract or approximately \$8 million for the family of test contracts.

The study resulted in two relatively diverse solutions to the EPA contingency fund requirement problem. The first solution noted in Table IV provides for an annualized EPA set-aside rate, which can be applied in any contract. The second solution, which is represented by the equations in Tables V and VII, is slightly more complex, but provides for separate calculations of EPA requirements for each contract. These calculations are based on the specific labor/standard industrial classification (SIC) codes and/or material/producer price indexes (PDI) codes applicable to each contract. This latter solution requires periodic forecasts of labor and material indices and the calculation process can be readily computerized.

A mathematical model of the current method of calculating EPA requirements is expressed in Table III. This model is wholly dependent upon the effectiveness of the selected percentage rate "R" as a predictor of the economic change. For "R" to be effective, you must consider and include a number of factors, such as: (1) the time period for contract execution; (2) the amount of the contract covered by the EPA clause; (3) the type of EPA clause (e.g., Actual Cost Method or Cost Index Method); and (4) the amount of economic change expected in the covered portion of the contract.

Table III
<u>Current EPA Model</u>

$$EPA\ (Total) = PR$$

EPA = Amount of Escalation Predicted
P = Contract Price
R = Selected Percentage

One improvement to the current method is to incorporate the time factor in the calculation model. This has been done as noted in the following equation depicted on the next table. This equation is an improvement over the current methodology because it accounts for the length of time over which the contract effort is expected to occur. The time frame is identified to be from the date the contract was signed through the date of final delivery. This includes all that time during which EPA affected material and/or direct labor can be applied to the deliverable item. Thus, a better judgment as compared to the previous method is possible, considering what percentage rate should be applied to estimate inflation on an annual basis.

Table IV
<u>General Model</u>

$$EPA = P\ (1+R)^N - 1$$

EPA = Amount of Escalation Predicted
P = Contract Price
R = Selected Annual Percentage Rate
N = Number of Years (months) in Contract

However, one would not be comfortable using this method without further investigation to assure its basis is sound. Nevertheless, it is felt that a generalized approach has some merit and warrants added effort to assess its validity. There are other problems inherent in the use of a generalized method. If there are wide variations in the percentage of EPA coverage on contracts, then there will be wide variations in the amount of funds reserved. Generally, the error will be on the conservative side and result in greater funds reserved than are needed. To avoid this conservatism and to increase the precision of the estimate, more specific methods can be employed which are tailored to the type of EPA clause on given contracts.

A model has also been developed for use on a contract which employs the Cost Index Method EPA provision as noted in Table V.

Table V
<u>Cost Index Model for EPA Computation</u>

$$EPA\ (Total) = EPA\ (Labor) + EPA\ (Material)$$

$$EPA\ (Labor) = \sum^{q}\sum^{i}\sum^{y}\left[\left(L_p \times L_{qa}\right)\ \frac{L_{qi} - L_{bi}}{L_{bi}}\right] P_y$$

$$EPA\ (Material) = \sum^{q}\sum^{i}\sum^{y}\left[\left(M_p \times M_{qa}\right)\ \frac{M_{qi} - M_{bi}}{M_{bi}}\right] P_y$$

Where:

q = Quarter
i = Index
y = Year
L_p/M_p = Percentage of Contract Price Covered by EPA Labor/Material
L_{qa}/M_{qa} = Allocation of L_p/M_p by Quarter (Expenditure Profile)
L_{qi}/M_{qi} = Forecasted Quarterly Index Value for Labor/Material
L_{bi}/M_{bi} = Base Index Value for Labor/Material
P_y = Contract Price by Program Year

Consider the application of this Cost Index Method Model where the EPA clause specifies the following:

a. The portion of contract labor and material to be covered by economic cost growth expressed as a percentage of the total contract price.

b. The "expenditure profile" for labor and material, which is usually expressed in quarterly increments over the life of the contract.

c. The specific price indexes to be used to measure changes in labor and/or material costs. These changes will be tied to a Bureau of Labor Statistics (BLS) index for one or more types or categories of labor and/or material. A base index value for labor and/or material as of an agreed upon date is specified as the level from which price changes are measured.

A typical example of data specified on a contract using the Cost Index Method is noted in Table VI, items 1 through 7.

Table VI
Typical Data Set
Cost Index Method

Data Element	Quarters 1	2	3	4	Total
1. Contract Price					$4,853K
2. Contract %-Labor					11%
3. Expend Profile-Labor	9%	29%	32%	30%	100%
4. Contract %-Material					32%
5. Expend Profile-Material	21%	31%	32%	16%	100%
6. Base Index-Labor					5.227
7. Base Index-Material					225.0
8. Forecast Index-Labor	5.293	5.398	5.503	5.610	
9. Forecast Index Material	230.3	235.3	240.2	245.1	

The real key to use of this model is that forecasted index values must be provided for the prescribed labor/material indices. In other words, changes from the base index value(s) specified in the contract must be predicted. It is recognized that this cannot be done with absolute precision, but it is believed that it can be done effectively and with relative ease. One method of prediction is the use of time series analysis. Many of the BLS indices are relatively stable and are not given to wide variation. Therefore, time series analysis provides reasonable accurate estimates of index movements. In other cases, specific judgments may be applied when economic factors are likely to cause extremes in price index changes.

Utilizing the data from Table VI in the Cost Index Model, the following results are obtained:

$$\begin{aligned}\text{EPA (Total)} &= \text{EPA (Labor)} + \text{EPA (Material)}\\ &= \$26K + \$86K\\ &= \$112K\end{aligned}$$

Using the current model or approach as noted in Table III:

$$\begin{aligned}\text{EPA (Total)} &= \text{Contract Price} \times 10\%\\ &= \$4,853K \times 10\%\\ &= \$485K\end{aligned}$$

As seen, a reduction of $373K in reserve funds would have been achieved using the Cost Index Model, or 2.3 percent in lieu of 10 percent.

For contracts specifying the Actual Cost Method of calculating EPA payments, the same general approach for computing requirements can be used. However, the basic requirements are in different terms than the Cost Index Method and a somewhat different calculating model is required. Such a model has been constructed and, as in the Cost Index Method, the calculations are simple but extensive. Therefore, the following shown is an expanded form of the Actual Cost Index Model.

Table VII
Actual Cost Model for EPA Computation

$$\text{EPA (Total)} = \text{EPA (Labor)} + \text{EPA (Material)}$$

$$\text{EPA (Labor)} = \sum^{y} \sum^{b} \left[\left[L_b \; (L_e-1)\right] \; (1+L_f)\right]_y$$

$$\text{EPA (Material)} = \sum^{y} \sum^{b} \left[M_b \; (M_e-1)\right]_y$$

Where:

y = Contract Period in Years
b = Base Costs as Specified in Contract
L_b/M_b = Labor/Material Base Cost
L_e/M_e = Labor/Material Cost Estimate Factor
L_f = Labor Fringe Benefits

All terms used in this model are specified in the contract except the "Labor/Material Cost Estimate Factor" which will be discussed shortly. The "Contract Period" covers the time from contract execution to final delivery, as cited for the General Model. The "Base Contract Costs" form the price level for that part of the contract to be measured for EPA payments. These costs are specified in the contract by individual labor operation and individual component prices.

The "Cost Estimate Factor" is a key element in the use of this model and can be likened to the Forecast Index value used in the Cost Index Model. The "Factor" is an estimate of the price changes to be expected on the measured portion of the contract. It can be derived in several ways. One way is to simply apply a value based on best judgment of how much the measured prices may change; e.g., 7 percent per annum. Perhaps a better method is to analyze the measured cost

elements and assign a proxy yardstick from the BLS index inventory. This done, changes anticipated in the price index level can be estimated using the methodology already described for the Cost Index Method.

The methodology of these cost models is not organizationally unique and can be applied by any organization using EPA clauses in procurement contracts. Use of the appropriate model reduced EPA contingency and requirements significantly. Also, use of the projection models will not significantly increase the risk of an over obligation of funds, a RS 3679 violation. Model usage will provide for prompt identification of excesses in committed funds as well as unobligated contingency funds or potential fund shortages on an individual contract basis. Additionally, models will provide a consistent, supportable rationale for the management and retention of EPA reserves. This obviously signals the potential applicability for use of these models in forecasting anticipated escalation prior to award which would allow for greater use of forward pricing techniques.

Summary

As noted by the BLS tracked data on the six year plotted actuals, escalation is predictable to a great degree.

While there are many instances in which an EPA provision cannot be avoided, we must consider all possibilities of forward pricing and continue and broaden attempts to encourage contractor sharing of the risk.

As the Office of Federal Procurement Policy espoused in their letter dated 31 Oct 78, subject: Anti-Inflation Measures in Federal Purchasing: We must ensure that EPA clauses are used only in circumstances where contingency or inflation factors are clearly beyond the control of the individual contractor. Contracts should normally be priced on a basis that considers all costs reasonably expected to be incurred during the period of performance. Thus, projections of performance costs which are based on economic trends that can be predicted with a reasonable degree of confidence should be considered in the initial negotiation of a contract price. The use of EPA clauses under this pricing concept should be limited.

CONTRACT NEGOTIATIONS VIA CLOSED-CIRCUIT TELEVISION

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ABSTRACT

The use of video conferences via closed-circuit television is proposed as a cost effective alternative for conducting or supplementing in-person contract negotiations due to increased travel costs and reduced television satellite transmission rates. In addition to providing background and implementation information, a number of potential applications are suggested in connection with the major defense systems acquisition process. The advantages and disadvantages resulting from such usage are also discussed.

INTRODUCTION

The rapidly escalating cost of air travel, hotel and motel rooms, restaurant meals, and car rentals has reached the point where both Government and industry are being forced to drastically curtail trips in order to live within planned travel budgets. Conversely, the cost per channel for satellite television transmissions has been steadily decreasing to the point where the cost per hour for a transcontinental hook-up is about $1,000 or less with correspondingly lower rates for shorter distances. The cost of ground stations has also been decreasing due to a combination of lower equipment costs and technological advances permitting the utilization of smaller diameter antennas.

Increasingly complex weapon systems and new acquisition initiatives continue to add to the ever present pressures to get programs under contract quickly. It therefore is also becoming more difficult to arrive at clear and concise contracts which define the program in sufficient detail so that it is well understood by both the contractor and the Government.

Two-way closed-circuit telecasts may now offer a practical alternative for conducting and/or supplementing contract negotiations/discussions and other portions of the source selection process for major defense systems acquisition programs in the 1980's.

BACKGROUND

As early as 1951, the first non-entertainment, conference-like telecasts were being produced by Smith, Kline, and French Laboratories for the education of physicians attending their annual meetings.(1) Using the CBS field-sequential color television system, operations and other forms of clinical medicine were telecast by beaming the signal from the originating hospital to a meeting location and projecting the resulting color image onto a large screen.

The construction of transcontinental microwave systems in the '50s made it technically possible to conduct closed-circuit video conferences, but the cost per hour of transmission of about $12,000 made its use prohibitive.

During the '60s, TelePrompTer Corporation used closed-circuit telecasts to theaters and hotels throughout the country for major boxing matches and the Indianapolis 500 automobile races. Theater Network Television and Management Television Systems produced many continuing medical education telecasts to multiple locations simultaneously by closed-circuit television. (In recent years, Tele Concepts in Communications, Inc. has joined them in perfecting this technique.)

In 1973, TelePrompTer Manhattan CATV Corporation produced the CATV industry's first live via satellite program from Jerusalem in honor of the 25th anniversary of the founding of Israel.(2) By that time, the cost of an hour of transmission via satellite from Israel had dropped to about $2,700.

Today, domestic satellite services are routinely available at highly competitive transmission rates. New satellite receiving locations are becoming available almost daily, and the FCC no longer regulates their installation. Private companies such as Home Box Office provide hours of television transmission every day to hundreds of CATV systems throughout America at nominal rates.(3)

In the interim, the cost of travel has almost doubled and is expected to continue to increase while the cost of television transmission has been steadily decreasing.

Virtually all of us have participated in contract negotiations conducted via long distance conference telephone calls. Participants from the Government side usually include the procurement contracting officer (PCO), cost analyst, and program or technical manager talking with their counterparts from the contractor side. Such negotiations have the advantage of saving one side or the other the wasted time and cost of traveling to and from the negotiation as well as being able to quickly gain access to specific individuals and/or back-up material that may be needed. Although such telephone negotiations do not normally involve major systems acquisitions, the essential elements are the same as is the desired end result.

The transition from a two-way telephone contract negotiation to a two-way television contract negotiation is a small one, and it is a logical extension of the uses of closed-circuit television or teleconferences that have been previously described.

As another precedent, closed-circuit television is now being used in a number of courts. A judge in Ohio currently uses videotapes of attorneys questioning witnesses in court proceedings to save time and money, and two-way closed-circuit telecasts between the courtroom and a witness in a distant city would presumably be equally admissible.

IMPLEMENTATION

Contract negotiations via closed-circuit television would usually be live two-way teleconferences consisting of televised signals, a means of transmission (microwave, land lines, satellite or a combination thereof), and viewing devices (television receivers or large screen TV projectors).

Origination. Negotiators on each side could meet in either a nearby regular television studio or one of their own conference rooms temporarily equipped with several television cameras, microphones and the control and switching equipment necessary for a remote pickup of the televised signal.

In a number of major cities such as Washington, New York, Chicago, Detroit, and Los Angeles, the Bell System operates teleconferencing centers which are available for such use at a nominal charge.

Local television stations and cable television or CATV systems also have studio origination facilities that are available for a minimal fee.

Technological developments in television camera picture tubes and microelectronics have made it possible to use hand-held television cameras with existing lighting for remote telecasts from almost any location.(4)

At each origination location, the television camera would focus on whomever was speaking with a second camera being used for longer shots showing the other participants. Name cards or place cards could be used to identify the names and titles of each of the participants.

Lapel microphones would be used for sound, and viewgraph machines and/or slide projectors could be used as they would in face-to-face negotiations as could a blackboard.

Transmission. A combination of microwave and AT&T land lines has traditionally served the closed-circuit teleconference originators for linking cities that are not far from each other. Now, as previously mentioned, new satellite transmitting and receiving locations are becoming available almost daily and the trend is toward more competition and lower rates.

Viewing. For viewing groups of 10 to 20 people in one location which would cover most contract negotiations, conventional television receivers could be placed so that each participant could view the proceedings. The Government negotiators would be watching and listening to the contractor's negotiating team on their television monitors and vice versa. For audiences of up to about 50, large-screen projectors providing an image of approximately 4 x 6 feet could be used.

POTENTIAL SOURCE SELECTION APPLICATIONS

Pre-Proposal Conferences. Television transmission in this case could be one-way from the originating command to regional viewing centers conveniently located near major concentrations of companies engaged in the defense industry. The use of an audio return via separate telephone lines would permit members of the audience at each regional viewing center to participate in the question and answer session.

Closed-circuit telecasts of pre-proposal conferences would permit the attendance of more key people from each potential offeror. Currently, space limitations at many commands make it necessary to restrict attendance to a handful of people from each company. A side effect of such remote telecasts would be the elimination of any opportunities for informal discussions between members of the Government team and representatives of potential bidders.

If audio questions did not have to be attributed to a particular individual or company, it might encourage a more open discussion of controversial issues in the Request for Proposal (RFP). It would also require the attendance of the appropriate Government personnel necessary to reply to such questions.

The cost of the closed-circuit telecast of a pre-proposal conference would have to be paid for by the originating acquisition activity, but could be offset by charging an admission fee for each attendee and/or company.

Offerors' Oral Proposal Presentations. For this purpose, the television transmission would be reversed from each of the participating offerors to the originating command. The offeror would be responsible for payment, but it would almost certainly be cost effective because typically offerors' oral proposal presentations involve a number of high level executive and program personnel who travel considerable distances for what is usually limited to a one or two hour formal briefing with no audience participation.

Televised oral proposal presentations would assure that each offeror would be treated equally and impartially, and each could be videotaped to provide a permanent record. The tapes could also be used as a reference during the source selection process by the Source Selection Advisory Council (SSAC) and Source Selection Evaluation Board (SSEB).

Discussions/Negotiations. This would involve a separate television transmission from the originating command to each of the offerors whose proposal was determined to be within the competitive range with an audio return. The cost would be paid for by the originating command.

At least 24 hours in advance of oral discussions at the originating command, the procurement contracting officer (PCO) supported by appropriate members of the contract definitization team would present a 30 to 60 minute summary of deficiencies to be discussed in the areas of design, performance, supportability, producibility, schedule, and cost aspects of the offeror's proposal as well as any items pertaining to contractual terms and conditions.

This pre-proposal discussion briefing would enable each offeror to include only the appropriate members of his proposal organization in the negotiating team at the oral discussions, and it would permit the offerors to be better prepared for more meaningful discussions with the contract definitization team in the limited amount of time available for such discussions/negotiations.

POTENTIAL SOLE SOURCE APPLICATIONS

Technical. Two-way closed-circuit telecasts between the procurement activity and the contractor would permit the full participation of all interested and responsible technical personnel from both sides. This is particularly applicable in an on-going program where the workload is such that technical personnel could not be spared to travel even if the costs involved were not a consideration.

Changes and corrections to the Statement of Work, Technical Requirements, or Specifications could be quickly re-typed off-camera, displayed on separate monitors, and reviewed and approved by both sides. (Word processors could be used to expedite this process, and the output could also be transmitted and displayed on a separate monitor.)

Data. Televised negotiations would permit responsible data management and functional organization personnel to quickly respond to and/or explain and defend requests for changes, and would facilitate the rapid review and approval of final Contract Data Requirement List (CDRL) items and Data Item Descriptions (DIDs).

Government Furnished Property. The participation of all responsible property administrators on both sides would be possible if negotiations were televised. It would ease the proper identification of part numbers, manufacturers, etc., and facilitate agreement on required quantities, need dates, location, availability, and modification/demodification schedules.

Delivery Schedules. Changes in delivery schedules could be easily coordinated with responsible activities on both sides, and final delivery schedules could be quickly reviewed and approved.

Terms and Conditions. Permits legal, patent and licensing, cost accounting, and other specialists to review problem areas first hand without entailing time consuming and expensive travel. As negotiations in this area typically involve exchanges of drafts and considerable coordination and review, teleconferences would facilitate reaching agreement on Special Provisions and applicable General Provisions.

Cost/Price. In terms of saving time and money, the use of two-way closed-circuit telecasts could be particularly rewarding for cost/price negotiations. Middle management and working level personnel on both sides would be readily available to personally explain and defend estimating rationale, and back-up data could be quickly located and provided as necessary to support items of particular interest.

If descoping or restructuring of the work statement becomes necessary, the resultant cost/price revisions could be more easily accommodated and negotiated through the use of two-way closed-circuit telecasts.

Finally, bottom-line negotiations could be expedited because both sides would have rapid access to executive level personnel responsible for approving the final contract.

POTENTIAL RESULTS

Advantages. The principal advantages resulting from the use of closed-circuit telecasts in the major defense system acquisition process are expected to be as follows:

1. Improved Planning. Telenegotiations would force both sides to do a better job of planning the agenda and the specific material to be covered at each session. Negotiating sessions would therefore be more efficient with the net effect of streamlining the entire negotiation.

2. Better Control. It is anticipated that the principal negotiators for each side would jointly be able to better control and schedule the negotiating sessions because of the necessity to reserve transmission time in advance.

3. Upgraded Quality. Both sides in almost any negotiation are occasionally guilty of wasting time on details rather than matters of substance, heated clashes between personalities, and individuals with a tendency to filibuster. The fact proceedings are being viewed on a television screen and videotaped should tend to minimize this kind of conduct and upgrade the quality of the negotiations.

4. Shortened Time Span. Elimination of the travel time involved in returning to and from home base to either gather, prepare, or coordinate additional or new data and/or negotiating positions plus the quick response and turn around time provided by telecasts should shorten the time span required to complete most negotiations.

5. Cost Effective. In many instances, the cost of utilizing closed-circuit television in connection with major defense systems acquisition programs should be less than the cost of the travel that would be involved in in-person discussions or presentations.

6. Assures Equal/Impartial Treatment. In competitive procurements, use of closed-circuit television would assure that all offerors received equal and impartial treatment.

7. Permanent Record. Videotapes of each closed-circuit telecast would provide an inexpensive permanent record of the entire negotiation, presentation, or briefing.

8. Ready Reference. In the event of a controversy or dispute over a particular point at any time during contract performance, that section of the videotape could be replayed to refresh both parties as to the intent of each at the time the contract was negotiated. The same thing would apply in the event of a protest by a contractor to the GAO and/or a dispute which goes to the Board of Contract Appeals or court.

9. Indoctrination. Since major defense systems acquisition programs extend over a number of years, the problem of changes in key personnel can be severe and particularly so when it involves people who participated in the original contract negotiation. With videotape records, each new person coming into the program could replay them and quickly be indoctrinated just as though he or she had been involved from the beginning of the program.(5)

10. Training. Videotapes should prove to be the best possible aid in training new or younger members of the acquisition process in the art of negotiation.

11. Less Physically Demanding. The reduced travel resulting from the use of closed-circuit television would make the entire negotiation process less physically demanding.

12. Better Defined Contracts. The final or bottom-line result of the use of closed-circuit television in the major defense systems acquisition process should be better defined contracts which are clearly understood by both the contractor and the Government.

Disadvantages. Some of the disadvantages that might result from the use of closed-circuit telecasts in the major defense systems acquisition process are as follows:

1. Impersonal. In comparision with across-the-table negotiations, closed-circuit television may seem impersonal and remote to the parties who have not met with each other personally beforehand.

2. Requires More Preparation. Closed-circuit television would probably involve more preparation in order to effectively utilize the transmission time. Negotiation team leaders could confer beforehand to ascertain both sides would be adequately prepared.

3. New/Unproven. Because the use of closed-circuit telecasts in connection with the major defense systems acquisition process is a new concept, it may meet with some resistance.

4. Implementation Difficulties. The logistics and mechanics involved in setting up closed-circuit television facilities may take time to implement in certain geographical locations.

5. Revised or New Strategies/Tactics. Use of closed-circuit telecasts could necessitate development of new or adjusted negotiating strategies and/or tactics. For example, it would probably reduce the viability of stalling as a negotiating tactic.(6)

6. Equal Treatment. In a competitive procurement, all offerors would be required to participate equally in any portions of the source selection process utilizing closed-circuit television.

7. High Visibility. Closed-circuit television would be certain to provide greater exposure and quick visibility to poorly prepared and/or inept negotiating personnel on both sides.

CONCLUSION

The objective of this paper has been to stimulate thought as to how this new medium could be used, what would be involved in using it, and the benefits and pitfalls that might be derived from doing so.

Like all new ideas, it will take time before contract negotiations are regularly being conducted via closed-circuit television. It will also require practical experience to learn how to best use this new tool.

Since the Department of Defense and the aerospace industry have jointly been primarily responsible for producing the technological advances that have made this possible, it seems only proper that it be used to advantage in the acquisition of affordable defense systems in the 1980's.

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CONTRACTING METHODS

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INCENTIVE CONTRACTING: THE UNDERLYING THEORY

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ABSTRACT

The underlying premise of microeconomic theory, financial management theory and of the Department of Defense acquisition process is the profit motive of the modern corporation. However, this assumption of profit orientation as the primary goal of the firm is only valid under the classical economic conditions of pure competition and owner-control of the firm. Without the discipline of competition and owner-control the profit maximization assumption is no longer necessarily valid. It is clear that in major system acquisition these conditions are not met. Therefore, other managerial goals may be significant motivators of the firm and its management. Examples of other goals can be found in the economic and psychological literature. According to those theories managers may seek to maximize or satisfy the following: sales, production, market share, salary, non-pecuniary benefits, perquisites, firm and managerial perpetuation and overall managerial utility. If the government just assumes one motive--the profit motive--they may not satisfy the managers' true goals which may be satisfied in a less costly manner than attempting to satisfy the secondary goal of profit.

INTRODUCTION

It is stated in Genesis that where discretion exists it is apt to be exercised, and that to merely charge someone to be a good and faithful servant is not adequate to secure his performance [35:3].

The Department of Defense attempts to limit a contractor's discretion in the acquisition process by writing contracts. In addition, in some contracts DOD uses monetary incentives to motivate certain actions in the areas of performance, costs and scheduling. These incentives are designed to encourage the contractor to make trade-offs that benefit the government. Ideally, the DOD would like the contractor to deliver a faster and more powerful weapon as early as possible for the cheapest cost. The contractor may have limited discretion concerning the cost and final performance of the system relative to its specifications but more discretion about the delivery date. In this case, the contracting officer may add a delivery date incentive to encourage early delivery.

Use of Incentives. Presently, almost one-third of the total dollars awarded by the DOD in large contracts ($10,000 or greater) are awarded in incentive (fixed price plus incentive (FPI) and cost plus incentive fee (CPF)) and award fee (CPAF) contracts (see Exhibit 1). In addition, almost 40 percent of the dollars are awarded in firm fixed price (FFP) type of contracts. If the contracts are measured by the number of actions rather than by the total value of award then the percentage of contracts that include an incentive or award fee drops to 4.1 percent and the percentage of contracts that include a firm fixed price dramatically jumps to 78.2 percent [10]. Thus, very large awards are more likely to include incentive fee provisions in their contracts than smaller awards. Conversely, smaller awards are more likely to have a firm fixed price type of contracts than larger awards.

Exhibit 1. Contract Type (1978 Fiscal Year)
DOD Actions Over $10,000

	Net Value ($000,000)		Number of Procurement Actions	
	$	%	#	%
Fixed price type	38,804	73.6	207,977	87.0
Firm	20,909	39.6	186,929	78.2
Redeterminable	927	1.8	3,696	1.5
Incentive	10,476	19.9	5,764	2.4
Escalation	6,491	12.3	11,588	4.8
Cost of Reimbursement type	11,779	26.3	25,577	10.7
No fee	1,175	2.2	3,819	1.6
Fixed fee	5,715	10.8	17,697	7.4
Incentive fee	5,134	9.7	2,983	1.2
Award fee	1,522	2.9	1,078	0.5
Other types	400	0.8	5,557	2.3
Time & materials	303	0.6	3,966	1.7
Labor hours	97	0.2	1,591	0.7

Source: Military Prime Contract Awards: Fiscal Year 1978.

The large use of incentive contracts and firm-fixed-price contracts can be traced directly back to the early sixties, specifically to the efforts of the former Secretary of Defense Robert S. McNamara

[4:4]. However, incentive contracts are by no means a recent innovation. Both the *Monitor* of the Civil War and the Wright brothers' "heavier-than-air-machine" were purchased with an incentive contract [4:8&9]. The *Monitor* had to float, attain a specified minimum speed, and win its first battle before the contractor was paid [4:8&9]. The Wright brothers received a $5,000 bonus added to their $25,000 contract when their flying machine exceeded the target speed by more than two miles per hour.

The DOD relies on two concepts to limit the discretion of the contractor and to encourage the contractor to make trade offs that benefit the government. First, the contract legally requires some actions and prohibits other actions. Second, the DOD expects the profit goal of the contractor to motivate him to complete the contract in a manner that is beneficial to the government. As the Defense Acquisition Regulation (DAR) states:

> Profit, generally, is the basic motive of business enterprise.... The objective should be to insure that outstandingly effective and economic performance is met with high profits, mediocre performance by mediocre profits, and poor performance by low profits or losses [9:3-22].

Incentive contracting in turn is based on DOD's belief that profit effectively motivates businesses. As DOD and NASA's somewhat outdated Incentive Contracting Guide states:

> The profit motive is the essence of incentive contracting. Incentive contracts utilize the drive for financial gain under risk conditions by rewarding the contractor through increased profit for attaining cost (and sometimes performance and schedule) levels more beneficial for the Government than expected (target) and by penalizing him through reduced profit for less than (target) expected levels [11].

However, the Guide also recognizes that other extracontractual factors can be significant motives. These extracontractual factors include the following: growth; new product line; prestige; better public image; social approval; national goals; potential for follow-on businesses; commercial application; excess manufacturing, engineering or labor capacity; increasing profits on other contracts by sharing the overhead; and excelling for the sake of excellence [11].

According to the Incentive Guide the DOD and NASA "recognizes that contractors will, generally, optimize--not maximize--profit" [11]. This, of course, follows Herbert A. Simons theory that a decision-maker can not possibly know all possible options, and thus, at best, he or she can only satisfy his or her goals rather than maximizing them [31]. The Guide recommends that when non-profit motives are apparent they should be considered when structuring incentive contracts [11:2]. This recommended use of "extracontractual motivators" is limited particularly since the DOD and NASA accept the concept that these factors are often beyond the control of the Government [11:ix]. The recommendation of the use of extracontractual motivators in this 1969 publication of the DOD and NASA have not been incorporated into the DAR in any significant manner.

DOD's basic position then is that in order for incentive contracting to be effective, defense contractors must be motivated by extra profits. An economist might say, the company's goals should be profit maximization or optimization. As Merton J. Peck and Frederic M. Scherer go a step further: "It is generally assumed that a major objective of contractors is to maximize profits, presumably by maximizing the price stated in a contract, and that these profit maximization efforts conflict with the government's goal of minimizing weapons cost" [28:457].

However, many observers question the importance of profit maximization to the average American company. In addition, much research has shown that incentive contracts are not as effective as expected [8]. These two observations may be related.

What then is the relationship between the profit maximization goal and the incentive contract? This paper will review the economic and management literature with an aim at determining the relationship. The review will search for the economic foundations and managerial infrastructure of incentive contracting.

THE THEORY OF THE FIRM

The classical economic explanation of the motivations of the business corporation is given by the theory of the firm. According to the theory of the firm, the entrepreneur's ultimate aim is the maximization of profits, where profits are defined as total revenues minus total costs [15:Chp. 3]. This theory assumes that the manager can vary both the output of the firm and the total costs. In addition, it assumes perfect competition which in economics meets the following conditions:

1. homogeneous commodity
2. numerous buyers and sellers
3. perfect information about prevailing prices and bids, and
4. entry into and exit from the market that can be accomplished in the long run [15:104].

These conditions are generally not met in the typical business transaction. Generally, buyers and sellers will deal with a differential product with less than perfect information about prevailing prices and bids. In addition, due to the concentration of market control by few firms there are not necessarily numerous sellers, and entry into a market may be very difficult.

In typical business-government transactions even fewer of these conditions are met. In a major

system acquisition often almost all conditions are violated. First, there is generally a customized product, e.g. a fighter aircraft or aircraft carrier. Second, there is only one buyer (a monopsony)--the U.S. government. Third, only the buyer has information concerning prevailing prices and that is only after the proposals are received. Fourth, entry into the manufacture of major weapon systems is very difficult indeed.

There are, however, some business-government transactions where many, if not all, of these conditions are met. For example, when the government purchases commercial items, such as paper clips, the assumptions of the theory of the firm may be met. However, in most major acquisitions, including those involving research and development, major systems and service contracts, the assumptions are clearly violated for no other reason than the fact that there is only one buyer. In addition, often there is but one source of the product. This situation of one buyer and one seller (bilateral monopoly) clearly violates the major assumption of perfect competition. The situation of a few sellers, like the shipbuilding and aircraft manufacturing industry, also violates the economic definition of a competitive market even though the DOD would assert that the market is competitive because there is more than one bidder.

Firm Behavior Without Perfect Competition. What theory then explains the behavior of firms in a imperfectly competitive setting? Unfortunately, there are no generally accepted behavioral assumptions outside of perfect competition except in monopoly (one seller and many buyers) and monopsony (one seller many buyers) market conditions. In the bilateral monopoly (one buyer and one seller) there are three general outcomes: (1) one of the participants will dominate and force the other to accept his price and/or quantity decisions, (the government intentionally tries to avoid doing this), (2) the buyer and seller may collude or bargain to set price and quantity, or (3) the market mechanism may break down [15]. Generally, the DOD attempts to negotiate contracts with a sole source under the second outcome--the buyer and seller bargaining to set the price--even though the quantity decision is generally set by the government. However, there are numerous examples where the other two outcomes have prevailed. In some cases the government has dominated the price and quantity decision. In other cases, due to superior or more experienced negotiations, the suppliers have dominated the pricing decision. Also, it is not difficult to cite instances where the market mechanism broke down, and price and quantity decisions were arbitarily set.

Since the assumptions for perfect competition are generally violated in business-government transactions the theory of the firm does not necessarily provide a reasonable explanation for the behavior of industrial suppliers. Under conditions of less than perfect competition the entrepreneur is given more managerial discretion to satisfy goals other than profit maximization. As will be seen, there are other reasons why a contractor may not behave as a profit maximizer.

Profit Motive. Just how strong is the profit motive? Robert N. Anthony stresses that managers strive for satisfactory profit but not a maximum profit. He argues that there are two basic reasons that managers will only seek satisfactory profits rather than maximum profits. The two reasons are that profit maximization is: (1) extremely difficult to achieve in practice, and (2) immoral [1: 129]. To apply the marginal pricing where each price is set at the point where marginal cost equals marginal price is exceedingly difficult when changing volume, selling and advertising costs are factored into the equation. Even a government contractor with all of the cost information available from the required detailed cost analysis will base its price on the total costs derived from its cost accounting system rather than on marginal income and costs.

Further, profit maximization may lead to immoral decisions that would clearly not be acceptable to the managers of an American corporation. For example, profit maximization would encourage the the contractor to take every possible short-cut that was not prohibited by the contract. If this meant future performance problems that would or could endanger a soldier's life or the national security of this country, a contractor wouldn't even consider such steps.

The profit maximization theory works well in the classroom where real world problems can be assumed away, however it does not work well in practice. In addition, managers are personally motivated by many other factors besides profits and incentives. These will at most only indirectly benefit from extremely high profits or incentive.

As Fritz Machlup stated in 1967 "Maximization of money profits is certainly the simplest 'objective function,' but it works only in the case of firms exposed to vigorous competition" (emphasis added) [25:22]. In other cases, managerial discretion and, thus, managerial and behavioral theories become important. Thus, profits may be important in a large number of DOD contracts where there is vigorous competition, other managerial and organizational factors may be important in major system acquisition where there is less competition.

Harvey Leibenstein incorporated these managerial and psychological factors into microeconomic theory [23]. He calls the individual managers level of effort the "x-efficiency" factor. This factor decreases directly with competition and ownership control and inversely with adversity.

Even with a profit sharing plan or bonus plan an extremely high profit on one contract or product will probably be diluted, because it will quite often be shared with other managers who may not even be directly involved with the profitable product. This dilution will decrease the effectiveness of profits as an incentive. In the organizational behavior literature, it is well established that the higher the relationship between individual effort and reward and between individual effort and performance the higher the motivation (see Atkinson [2], Lawler [22], and Vroom [34]). Thus,

for profit to be a motivator there needs to be a direct link between corporate or project profits and rewards for the project director and other decision-makers including the engineers and production managers. Unfortunately, due to the length of the projects this direct relationship is diluted at best.

Managers will be influenced by many immediate concerns, such as employee morale, and production schedules, and with long range concerns, such as, firm perpetuation and managerial perpetuation (keeping one's own job). These other goals will out weigh the firm's goals unless they are operationized. In that case, the firm will set such goals as certain levels of profits, sales productions, costs, or quality that managers should achieve. Since these are a priori goals and are consequently not maximums; rather they tend to be satisfactory and attainable. Just by setting multiple goals for the manager, the firm is encouraging the managers to make trade-offs on the stated and unstated goals of the firm. Thus, the manager is encouraged not to maximize a specific goal but to satisfy as many as possible. In addition, the manager will seek to satisfy other non-quantifiable goals such as, employee morale, customer satisfaction and relations, supplier relations, and perhaps community relations.

The fact that profit maximization is not the only goal or even the primary goal of the firm does not mean that contractors are not motivated by profits. What it does mean, however, it that there are other motivators that the government could use in its contracting with private firms.

Managerial Discretion. As previously seen the four criteria for perfect competition in the firm which lead to the classical profit maximization goal are not generally met in the major system acquisition transaction. Most importantly the theory of the firm assumes that the decision-maker of the corporation is an entrepreneur, that is the owner-manager.

It has been clearly established that the managers of the typical large corporations in America are not the owners. In 1932, Adolf A. Berle, Jr. and Gardiner C. Means found that only 11 percent of the 200 largest corporations in the United States were controlled by individuals or a small group that had more than 50 percent of the outstanding stock [5:115]. Another 33 percent of those corporations were controlled by a small group of investors that held more than 20 percent but less than 50 percent of the stock. Thus, the majority of those firms were not controlled by the owners. More recently Larner [21] confirmed this separation of ownership and control.

In 1776, Adam Smith pointed out that managers that are not owners would be less efficient than owner-managers. He argued that the managers of other people's money would be less concerned than if it were their own. He went on to argue that "negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such a company" [32:700].

Modern students of business behavior use kinder words to describe the behavior of managers. The behavioral theories assume rational actions on the part of managers, but those actions are based on the need to satisfy other goals besides profit maximization. In any case, it is important to examine behavioral theories of the firm to better understand the management of government suppliers.

Besides the theory of the firm there are two primary sets of theories that attempt to explain the behavior of the business enterprise. First, the holistic theories which assume that the firm acts as a single entity with homogeneous behavior [29:22-24]. These theories implicitly assume that a central force directs all individual actions of the managers of the firm. One way of seeing this strong goal orientation on the part of the firm is in the directions and directives of top management which are in turn followed by all of the decision-makers of the firm. Second, the behavioral theories assume that all of the managers will individually determine the objectives of the firm. These individual actions will be constrained by the organization's goals but will not necessarily reflect those goals precisely. These behavioral theories are, in effect, saying that top management can influence but not necessarily dictate the firm's behavior, since that behavior depends on the actions of many individuals.

All firms have some characteristics of a "holistic" organization where all managers speak with one voice. At the same time all firms have some behavioral characteristics where each manager has some discretion to interpret the needs of the organization. The firms differ in degree of control over the managers. Thus, even in an apparently tightly controlled centralized organization behavioral theories are important because there remains some degree of freedom for managerial discretion.

THE FORMATION OF THE FIRM'S GOALS

The goals of the firm evolve from the top management of the company. Goal formation is influenced by the needs not only of the shareholders, but also of other internal and external groups. Most prominent of the internal groups are the managers themselves. Gordon Donaldson sees managers as a whole aspiring to continuity and growth, not to profit maximization [12:129]. The continuity of the firm and more directly the continuity of the manager's own job are often most important to the individual decision-maker. Other influential internal groups consist of the employees and their representative union. The managers must also balance the needs and interests of external groups including customers, suppliers, government regulators, trade and professional associations and shareholders against the internal group of employees and themselves. Thus, the profit maximization goal of the shareholders is but one of many competing potential goals of the organization. As Anthony of Harvard pointed out, profit maximization is not necessarily the primary goal of many organizations [1:127]. "Profit maximization," he further claimed, "is not a valid assumption to explain how

businessmen actually behave or how they should behave" [1:126]. This observation, of course, differs sharply from the profit goal assumption of the DAR and many microeconomists.

The other long-term goals of the firm include sales maximization, asset maximization, product quality, good community relations, good employee relations, customer and supplier loyalty, technological base, corporate image and market share.

It is not clear whether the lack of competition or the separation of ownership and control leads to managerial discretion. Still, according to Furuboth and Pejovich [14:1149] both conditions have an effect on the profit maximization goal. They agree with Williamson [35] when they conclude that "the general consequence [of the separation of ownership and control and negative sloping demand curve] is that the managers are able to pursue their own goals within certain limits and, thus, tend to direct the firm away from the profit maximizing position that represents the owners' desideratium." To be sure, management's freedom of action is effectively controlled by competition in a highly competitive market, as Machlup has argued. However, as pointed out earlier, most major weapon systems acquisitions are not in what economists would define as competitive markets, even though they are defined as competitive by the requirements of the DAR.

NON-PROFIT MAXIMIZATION GOALS

If profit is not the primary motive of corporation, what are the other theoretical goals of the firm? William T. Baumol suggests that the firm's primary objective is the maximization of sales or the rate of growth of sales [3]. Baumol argues that declining sales may cause the customers, distributors and bankers to shun the company and its products. A good example of the phenomena of customers, dealers and bankers negative reaction to declining sales is Chrysler Corporation's automobile sales. Chrysler has had to offer rebates and numerous assurances that it will not fail just to get its potential customers into the showroom. Baumol treats profits as a constraint that must be fulfilled.

Oliver E. Williamson argues that the manager will strive to maximize his or her personal utility [35]. According to his theory, when the natural constraints of owner control and vigorous competition are absent, the manager's actions will reflect his or her individual interests such as increasing staff size and increasing financial rewards including salary and perquisites [35:Chps. 4&5]. Michael Jensen and William H. Meckling hypothesize that managers will also increase their non-pecuniary benefits (such as office space, air conditioning and carpets increases) [19]. With both Williamson's and Jensen and Meckling's theories as with the sales maximization theory, profit is a minimum constraint that should be satisfied. In perfect competition Williamson's theoretical solution approaches profit maximization.

Finally, Robin Marris theorizes that firms will attempt to maximize the growth rate of the demand for the firm's products and of the firm's productive capacity [26]. As with the earlier theories, Marris' model uses a target rate of return or a minimum profit level that is consistent with a balanced long-run growth rate. Profits are necessary both for survival and growth, and growth is often necessary for survival [26:Chps. 6&7]. Many of these goals lead, to some extent, to profits. However, in many cases these other goals will cause profits to drop. Good employee relations may increase the cost of production. Maximizing sales or market share may require that the goods and services be sold below their marginal or average cost. A recent case in point is Sears, Roebuck and Company. The company attempted to regain lost market share by having increased promotions and sales. This strategy succeeded in raising the company's market share, but it also lead to a drop in earnings per share.

In addition, the firm may have a series of short-term goals to support its long-term objectives. Examples of short-term goals may be a certain production, employment, cash flow or research and development level.

SOME MITIGATING FACTORS

From all of the literature that we have reviewed, we can conclude that the theory of profit maximization has been attacked from three perspectives: the separation of ownership and control, the lack of pure competition, and the impossibility of maximizing which is replaced by satisficing. The behavioral studies of management also call into question the primacy of the profit maximization goal.

Still, we must keep in mind several mitigating factors that insure that firms have at least a minimum profit goals. First, the capital markets may indeed influence managers to act in the owners' interest. This effect may be influenced by the fact much of the managers' total compensation is in the form of returns from presently owned stock and from capital appreciation of the value of their stock options (Lewellen [24], Machlup [25], and Larner [21]). The capital markets may also act as an effective constraint on the top managers because of a fear of a takeover by non-friendly owners if the present shareholders' objectives are not met (Marris [26] and Hindley [17]). The diffused ownership permits greater specialization among the shareholders, according to De Alessi [7: 842-3]. This in turn induces better informed owners to react sooner and more accurately to an inefficient operation, thereby lowering the stock's market price and cost of taking over the firm (De Alessi [7:843]).

The second constraint on the behavior of the management is the competition within the market place which tends to eliminate inefficient firms with high managerial costs or non-profit goals (Machlup [25], De Alessi [7], and Sorensen [33]).

Finally, the third constraint that appears to be operational, according to De Alessi [7], is internal competition among the managers within one corporation. As the individual managers vie for promotions and pay increases, they will attempt to maximize the measurable objectives of the corporation, one of which may be profit.

ECONOMIC AND BEHAVIORAL THEORIES AND THEIR APPLICATION TO THE DOD

The preceeding economic and behavioral theories apply to firms in general. Still we may ask if they apply specifically to DOD contractors? The answer is that they do. Government/contractor relationships have some unique characteristic, such as, government supplied equipment, but, in general, the contractors tend to behave like all commercial firms. A thorough and rigorous analysis of the economic motivations of contractors was conducted by Professor Raymond C. Hunt of the State University of New York at Buffalo. After an extensive review of the literature, a questionnaire, and interviews, Hunt concluded:

> If we had to identify a single over-arching company motive...(at least the R & D corporation participating in this research) it would not be profit-seeking; we would probably call it 'mastery'--a desire to be in control of one's own fate, to be able to conduct affairs as one wished and to be good at it.
>
> This motivational orientation subsumes most other 'needs' as instruments for its achievement. Profit, for example, is a way of accumulating capital resources allowing an organization to make decisions partially independent of its customers [18:151].

In general, Hunt concludes that R&D contractors are basically a "risk averse group of firms...(that could) best (be) described as 'profit satisficers'" [18:297]. In an experiment with sixteen undergraduates, Feeney, McClothlin, and Wolfson of the RAND Corporation also found that the profits sought increased with uncertainty [13:v], which again implies risk averse behavior. It should be noted, however, that the motives of an organization can only be determined by inference--by studying its behavior or surveying the component members of the organization. It is the individual members that collectively define the motives of an organization. Consequently, an incentive must be perceived as a reward to the decision-makers of the organization.

Hunt's work implies that incentive contracts can be written to accomplish that goal. However, Hill and Shepard's Naval Postgraduate School's thesis question whether incentive clauses really motivate middle managers [16:41]. Since they found no profit maximization scheme in the seven companies they survey, they questioned whether profit incentives could be motivators [16:41]. However, in another limited study, Julius E. Jones and Russel Pierre, Jr. found support for firm perpetuation, sales maximization and profit maximization as the goals of the defense contractors.

Peck and Scherer suggest other non-profit maximization behavior such as maintaining unnecessarily large staffs to avoid the unpleasant task of laying off personnel [28:458]. Thus, it clearly appears that the non-profit maximization goals do apply to government contractors.

Therefore, it is essential to understand the multiple goals of the DOD contractor: the goals of sales maximization, firm perpetuations, engineering staff and employee continuation, market share, R&D knowledge and expertise, technological innovation and base, risk reduction with long production runs, managerial job satisfaction, corporate image, employee relations, and supplier loyalty will not necessarily raise the cost of the acquisition process. Exhibit 2 shows how price only partially satisfies the multiple goals of the decision-makers. As can be seen, just the awarding of the contract to a firm will satisfy many of the managerials goals without concern as to the level of profits as long as they are at or above the minimum satisfactory level. These other goals may in fact lower the governments overall costs if the contracts can be written to satisfy one or more of these non-profit goals. For example, multi-year contracting--a dream of many contract officers--will enable the contractor not only to spread the overhead costs over a longer period of time, but also to increase the firm's perpetuation. This risk reduction may encourage the contractors to lower the level of satisfactory profit (and, thus, price) on any one contract. In addition, the government may allow a contractor to build up a unique technology base that can be used for its defense as well as for its commercial business if this means lower overall costs to the government without creating a government sole source and a commercial monopoly.

Innovative contracting may also lead to lower priced contracts. For example, Jack R. Runkle and Cerald D. Schmidt found that the frequency of award-fee contracts evaluation meetings and the level of the fee determination officer (FDO) is directly related to the firm's contract performance [30]. Thus, for little additional cost (primarily administrative costs) the government is able to motivate managers, and thus their firms, without excessive profits.

CONCLUSION

Since the profit motive is not the only theoretically correct objective of a firm, it is important that government attempt to tap other goals in the acquisition process. Because managers generally attempt to avoid risk, the government could reduce firm perpetuation risk by signing multi-year contracts. Since managers attempt to satisfy personal needs, such as prestige and job satisfaction, the government might be able to meet these needs by frequent reviews like the award fee review process. Again, as the government attempts to meet these non-profit goals, the overall costs of the contract may be lowered since profit is

Exhibit 2. Government Techniques to Motivate Firm's

Government-Tools for Motivating

Firm/Managers' Goals

1**Firm Survival
1 *Firm Growth (employees, sales, assets or profit)
*Market Share
1**Managerial Perpetuation (keeping one's own job)
1 *Using Surplus Capacity (employees, equipment or facilities)
1 *Share Overhead of Other Products and Projects
1 *Technological Improvements
*Research and Development

Contract Price → Profit

**Personal Promotion and Recognition
1**Personal Utility
*Business Base
**Prestige
1 *Business Risk Reduction
*Diversification of Product Line
*Sales
1**Future Commercial Application
*Patriotism

Key

→ Direct Relationship with Contract Price
– – → Indirect Relationship with Contract Price
* Direct Relationship with the Award of the Contract
** Possible Indirect Relationship with the Award of the Contract
1 Contract Requirements and Specifications may Limit the Fulfillment of this Goal

not exclusively relied upon to motivate the contractor.

Over the last fifteen years a number of researchers have studied the effectiveness of incentives based on profit maximizing. The approaches used have been as rigorous as the data would support; as creative as the researchers could devise. None, has unequivocally supported the efficiency of the incentives to achieve the expected goals. Yet, regulatory guidance continues to be stress the profit motive.

While a proportion of contracts let in a competitive mixed defense/commercial market may favor a profit maximizing approach, the preponderance of dollars awarded do not. In fact, there is much evidence to suggest that a more balanced approach to DAR profit policy is supported by the weight of evidence. The time for a change is now!

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SECOND SOURCING IN MAJOR SYSTEM ACQUISITIONS

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In the present atmosphere of decreasing Defense budgets, it becomes imperative that each and every person responsible for the acquisition of major weapon systems be on the lookout for ways to improve the acquisition process. One tactic which may, in selected instances, result in the realization of significant benefit to the government is "Second Sourcing". Unfortunately, the policy guidance presently available to Program Managers provides little direction relative to second sourcing and production competition. The major objectives of this research, then, were to (1) delineate the potential reasons for second sourcing; (2) develop a description of the methods available for generating a second source; (3) identify the factors involved in evaluating the feasibility of second sourcing a given acquisition; and (4) formulate a model to assist the Program Manager in selecting the most appropriate second sourcing methodology.

PREFACE

Second Sourcing (the establishment of two or more qualified and independent sources for the production of hardware to satisfy a mission need) is a term that is widely recognized in the acquisition community; however, there is little familiarity with the various methodologies that may be used in establishing a viable second source. Since there are a number of techniques for establishing a second source for production of a weapon system, the process of deciding which, if any, of these techniques to use should follow a logical series of steps: (1) specific objectives/policy goals to be fulfilled must be clearly stated and understood, (2) a determination must be made as to the adaptability of the project in question to second sourcing, and, (3) the acquisition alternative that will best achieve the stated goals must be selected. Among the potential reasons for establishing a second source are the following:

(1) Broadening the production base.
(2) Evening out the fluctuation in the defense industry which leads to feast or famine situations for individual firms.
(3) Achieving savings through increased competition.
(4) Achieving superior equipment through increased competition.
(5) Facilitating North Atlantic Treaty Organization (NATO) participation as coproducers or through offsetting coproduction as subcontractors.
(6) Facilitating the attainment of socio-economic goals by increased award to minority and small business contractors.
(7) Preserving competition for the sake of competition per se.(1)

It is fully conceivable that some of these objectives may, in fact, be in conflict. If such is the case, a determination must be made as to the relative importance of said objectives so that those having the greatest impact may be considered as controlling.

Once the reasons for second sourcing have been established, the Program Manager and/or the Contracting Officer must decide (1) whether or not the generation of a second source is feasible, and (2) which second sourcing methodology is best suited to the given acquisition situation. The Second Sourcing Method Selection Model (SSMSM) which will be presented later in this paper and is designed to help the Program Manager in making these decisions.

METHODS OF GENERATING SECOND SOURCES

Although this paper will discuss only five methods which can be used to provide two or more sources for production of a weapon system, these five are not to be considered as being all inclusive. The five methods are: form-fit-function, technical data package, directed licensing, leader-follower, and contractor teams. It should be emphasized that, where possible, the decision of whether or not to pursue second sourcing be made as early as possible in the life of the program so that the development contracts can be structured to facilitate the technology transfer which is essential to production competition. If the Program Manager waits until the design selection is made to consider production competition, he will encounter stiff and possibly insurmountable opposition from the "other half" of the bilateral monopoly which he has created.

Form-Fit-Function (F^3). This method involves introduction of a second production source without need for a technical data package or for interaction between production sources. The second

source is provided with functional specifications regarding such parameters as overall performance, size, weight, external configuration and mounting provisions, and, interface requirements. This is the classic "black box" concept where it is not necessary to define the internal workings of the product. It is used frequently for the acquisition of expendable nonrepairable items where the ability of the system to perform as required is not dependent on what is inside the "box". The method does not work well where field level maintenance of the system is envisioned since the provision of nonidentical items make stockage of repair parts and training of maintenance personnel potentially insurmountable problems. These objections can sometimes be overcome by the use of warranty provisions, renewable maintenance contract provisions and/or provisions for contractor services to set up the necessary government maintenance capabilities to support the equipment throughout its lifetime. The advantages of acquisition by F^3 specifications include:

(1) Detailed design responsibility is clearly assigned to the contractor. If the item fails to meet specifications, the contractor must alter the design until specified operation is achieved.
(2) There is no design data package for the government to procure or maintain.
(3) Requirements for technical capability within the government are minimized. This is the path of least involvement on the part of the government in contracting, contract monitoring, etc.
(4) Standardization can be achieved among multiple sources through two-way interchangeability of products which may differ internally. These multiple sources may be exercised simultaneously.

The disadvantages include the following:

(1) Each procurement contains a development effort unless the product is off-the-shelf modified. Some time and money are involved each time the item is procured for engineering, changes, production learning curves, and debugging.
(2) Each time an acquisition is made, the contractor who has the least appreciation for the total significance of the specifications and the effort to accomplish the task is likely to be the low bidder. This means the source selection criteria must be very carefully constructed to include mechanisms to demonstrate contractor awareness of critical elements as well as his capabilities to produce the item.
(3) The costs of repair parts will tend to become excessive when a contractor realizes that he is in a somewhat sole-source position with respect to his equipment unless the total maintenance for the service life of the equipment is provided for in the procurement contract while competition is still being maintained.
(4) Careful specification of all external parameters is required to ensure true interchangeability.(2)

Technical Data Package (TDP). This method involves utilization of a stand alone TDP to solicit proposals from manufacturers who may not have been involved in initial production. Ordinarily this is accomplished through the invocation of an appropriate data rights clause in the original Research and Development (R&D) or initial production contract. Even where no such clause exists, it may be possible to buy the data package subsequent to production. In the absence of such a clause, the original developer/producer may consider the design, or portions of it, to be proprietary; and, hence, may be reluctant to provide a complete TDP to the government. The cost of acquiring the data package subsequent to initial production may thus be prohibitive. This method assumes that the data package alone is sufficient to allow production of the system by alternate manufacturers. Although it has been successfully utilized, there are frequent examples where significant difficulties have been faced in applying the method. Its chief attraction is that the existence of an adequate data package can result in the maintenance of a competitive environment throughout the life of the project.

Although theoretically sound, this method is perhaps the most hazardous of all the second sourcing methodologies. It is not well suited for use with highly complex systems or systems with unstable design or technologies. Experience has shown that drawings and specifications alone are often insufficient to secure effective transfer of manufacturing technology. "The critical factors may be craftsman's skills, ingenious processes, 'tricks of the trade' and esoteric shop practices that cannot be reduced to formal or informal paper."(3) Once the data package has been accepted from the developer, the government effectively guarantees its accuracy and adequacy to the second source. If defects are subsequently discovered in the TDP, as is almost always the case, the second source may have the basis for a claim against the government. Some methods of minimizing this particular problem include: requiring the producer of the data package to certify its adequacy; pre-production evaluation by the second source; and, the use of a latent/patent defects clause in the contract with the second source, to name a few. The use of a latent/patent defects clause, however, is experiencing significant disfavor because it is being maintained by many legal representatives that the mere existence of such a clause is tantamount to governmental acknowledgement of the inadequacy of the package. This puts the government in a precarious legal position in the event of subsequent claims.

There are other problems associated with the TDP approach. Although there are those who maintain that if the system was developed under government contract, there should be no proprietary rights to any of the data; the fact remains that much of the data required for successful technology transfer may be encumbered with claims that the information is proprietary. These problems center on the definition of "proprietary data" and "trade secrets" and on whether or not the government has the right to require the dissemination of such information.

The major advantages of second sourcing via the TDP include:

(1) The TDP can be used repeatedly in maintaining a competitive atmosphere throughout the production phase of the acquisition.
(2) Once the TDP is validated and proven adequate for production of the system, the mechanics of second sourcing are relatively simple. There need not be any contract between production sources and it is even possible to eliminate the original source altogether.

The primary disadvantages of the method are:

(1) It may be exceptionally difficult to obtain a complete and accurate TDP that is free of encumberances and which, when followed, will yield a qualified product.
(2) The acquiring authority must have access to whatever "in-house" talent is necessary to ensure resolution of data package problems.
(3) Even where drawings and specifications are complete and accurate, transfer of complex technology is often impossible without the benefit of engineering liaison between sources of production.
(4) Technological differences between companies (e.g., differing process methodologies) may be such that the second source does not have the capability of performance in accordance with the data package.

Directed Licensing (DL). In its pure form, this method involves the inclusion of a clause in the early development contract allowing the government to reopen competition for follow-on production, select a winner, and appoint him as a licensee. Then, in return for royalty and/or technical assistance fees, the licensor (development contractor) will provide the licensee with manufacturing data and technical assistance to help the second source become a successful producer.

As used in many current acquisitions, licensing agreements are also being negotiated where no provision for such an agreement was included in the development contract. Such arrangements may, however, be considerably more costly than those specified in the original development contracts. There has also been a trend toward allowing the licensor to choose his own licensee -- subject to government approval.

This method involves not only the transfer of data from the developer to the second source, but also provides for the transfer of manufacturing "know-how". The developer is normally awarded the first production contract and is contractually bound to licensing another contractor for production of an unspecified number of future systems. In fact, the provisions of the licensing agreement (including royalty fees; if any) should normally become one of the source selection criteria used in choosing the winning developer.

DL seeks to solve technology transfer problems associated with the TDP methodology by providing for necessary engineering and manufacturing liaison between the sources which is then incentivized through the royalty procedure. It derives its attractiveness from the fact that subsequent acquisitions can be competed -- in whole or in part -- even where complex systems technology is involved.

Promising as DL may appear, it does entail the incursion of significant identifiable costs. If the royalty fee is unreasonable, the benefits of competing the production buys will be significantly reduced. If, however, the developer can provide an acceptable product at a lower price than could a second source, the government need not exercise the licensing option. The mere threat of competitive options may be a sufficient incentive for the developer to maintain efficiency and keep costs to a minimum.

The advantages of DL include:

(1) The potential for production competition is maintained throughout the acquisition cycle.
(2) The government need not become closely involved with the actual transfer of technology between sources.
(3) Quantity production decisions and source of supply decisions can be postponed until later in the acquisition process.
(4) The designer is provided with protection as to how, or in what markets, the second source is to be licensed to sell the product; and, the designer is compensated for each item produced by the second source.

The disadvantages of DL include:

(1) The existence of royalty and technical assistance fees increases the cost of the acquisition and could be prohibitive.
(2) It may be difficult to achieve the necessary degree of cooperation between alternative production sources, and the licensee may have little recourse against halfhearted cooperation on the part of the licensor.
(3) Some contractors may bid on projects simply to obtain proprietary information on other producers' designs.
(4) It may become difficult to maintain design accountability.

Leader-Follower (LF). The Defense Acquisition Regulation (DAR) defines LF as "an extraordinary procurement technique under which the developer or sole producer or an item or system (the leader company) furnishes manufacturing assistance and know-how or otherwise enables a follower company to become a source of supply for the item or system". DAR limits the use of this technique to situations when all of the following conditions are present:

(1) The leader company possesses the necessary production know-how and is able to furnish

the requisite assistance to the follower.

(2) No source of supply (other than a leader company) would be able to meet the government's requirements without the assistance of a leader company.

(3) The assistance required of the leader company is limited to that which is essential to enable the follower company to produce the items.

(4) The government reserves the rights to approve contracts between the leader and follower companies.

DAR suggests the following three methods for establishing a LF relationship (no preference is indicated as to which method should be used):

(1) One procedure is to award a prime contract to an established source (leader company) in which the source is obligated to subcontract a designated portion of the total number of end items required to a specified subcontractor (follower company) and to assist the follower company in that production.

(2) A second procedure is to award a prime contract to the leader company for the requisite assistance to the follower company, and another prime contract to the follower company for production of the items.

(3) A third procedure is to award a prime contract to the follower company for the items, under which the follower company is obligated to subcontract with a designated leader company for the requisite assistance.

LF acquisitions have been undertaken in the past more for the purpose of meeting delivery schedule requirements due to the lack of capacity of a single source, rather than for increasing competition. However, since the concept encompasses dual or parallel production lines, splitting the award quantity on a high-low percentage basis would still insure a significant degree of competition for the annual production contracts.

The advantages of LF are similar to those of DL in that:

(1) It provides a technique for transferring part or all of the production of a complex system to a second source.

(2) Competition can be utilized to determine the acquisition split awarded to each qualified producer even when two sources are maintained throughout the acquisition cycle.

(3) It has been used successfully in the past.

The major disadvantage of the LF technique is:

(1) "Leader" companies may be less enthusiastic about this technique than DL because LF contains no royalty provisions for proprietary data nor does it provide some of the protection that may be present in a licensing arrangement.

Contractor Teams (CT). A recent innovation in the generation of production competition is represented by the CT which are currently competing in the design selection phase of the Airborne Self-Protection Jammer (ASPJ) system. In the solicitation for the design of the ASPJ, the Naval Air Systems Command (NAVAIR) required that offerors form teams of two or more contractors. The acquisition strategy envisions the award of a production contract to the team which eventually wins the design competition. Following initial production, both contractors are expected to have the capability to produce the complete system. DAR provides a brief discussion of CT including a policy statement on the use of teaming arrangements. The implication of DAR is that the government will generally permit CT, but it does not mention actions by the government to require the formation of teams as was done on the ASPJ. DAR does mention that some contractor teaming arrangements may violate anti-trust statutes. The Program Manager and/or the Contracting Officer must be sensitive to this possibility in order to prevent its occurrence.

The advantages of requiring CT are:

(1) It should prevent most of the problems in qualifying a second source, since at least two contractors were involved in the design and initial production.

(2) It should also reduce or eliminate the feeling on the part of either contractor that trade secrets or proprietary data are being given away to outside sources.

(3) No liaison fees or royalties will be involved in the establishment of the second source.

(4) The design talent of two contractors will be brought to bear on each proposal, thereby increasing the opportunity for successful and innovative designs.

(5) It provides a vehicle for increasing the capacity of the industrial base.

The disadvantages of CT are:

(1) The design phase may be more costly since at least two contractors are involved on every proposal.

(2) It requires a great deal of cooperation and coordination by the contractors.

VARIABLES AFFECTING THE PRODUCTION COMPETITION DECISION

The selection of the "best" method for generating production competition will vary depending on a number of factors extant in any acquisition program. The existence of these factors (i.e., decision variables) presents the Program Manager with a difficult, multi-faceted decision situation. He must consider the strengths and weaknesses of each competitive method in relation to the influence of the variables in his acquisition program.

In order to assist the Program Manager in logically and systematically selecting the optimal

competitive method, an evaluation model is needed. The model should rank each of the competition techniques against each of the decision variables. Then, by objectively evaluating the influence of each of the variables, the Program Manager will be led to an optimal choice of which method of competition to use in his program. At a minimum, one or two of the methods may be shown to be clearly superior to the others, thereby reducing the complexity of the decision situation.

Before describing such a model, however, it is necessary to define the decision variables on which the model is based and to describe the general impact which each of the variables has on the feasibility of production competition.

SECOND SOURCE DECISION VARIABLES

Quantity to be Procured. The ultimate quantity to be procured and the rate at which the government will place orders for production will have a significant effect on the adaptability of the project to second sourcing. In general, the larger the quantity to be procured, the more feasible it is to have production competition. The ideal situation for second sourcing would entail large quantities needed at a rapid rate over a number of years. Any deviation from this ideal will tend to lessen the cost effectiveness of generating a second source.

Duration of Production. As alluded to above, it is generally true that the longer the duration of the projected production, the more feasible second sourcing becomes. For example, suppose the production phase is to be only four years long, and it takes at least two years to bring a second source on line (including source selection, start-up of the plant, and production of a learning/ qualification quantity). In this case, there would be only a year or so left for production of the system by the second source, in which case second sourcing would be an inappropriate strategy.

Slope of the Learning Curve. The flatter the slope of the learning curve, the more adaptable the project becomes to second sourcing. With a steep learning curve, the more units produced by the original source before a second source is brought "on-line", the more unlikely it becomes that the second source can effectively compete with that original producer who is, by then, a more experienced and efficient producer.

Complexity of the System. The more complex the system, the more essential is the need for cooperation and liaison between the two production sources, and the less adaptable is the project to second sourcing.

Other Potential Government or Commercial Applications. If the system has wide applicability for other government or commercial uses, the original developer is more likely to demand some form of protection for his "trade secrets" or "proprietary data" than if the market for the product is very limited. On the other hand, the interest of potential second sources in the project will be stimulated if other applications for hardware exist.

Degree of Privately Funded R&D. The greater the degree of privately funded R&D on which the design is based, the more reluctant the developer will be to release his design to a second source. This is particularly true if no restrictions are placed on the use of the design by that second source.

Cost of Unique Tooling/Facilities. As special tooling/facilities requirements and costs increase, the number of potential second sources decreases and the probability of being able to bring a second source on line in a cost effective manner decreases. Also pertinent will be other start up and nonrecurring costs, including first article acceptance testing. The higher these costs become, the more difficult it is to amortize them over the duration of the acquisition.

Maintenance Concept to be Employed. Second sourcing, with its multiple producers, can have significant impact on the maintenance considerations of the system. Wherever two systems of the same type are nonidentical, the ability to support those systems with field level repair parts and maintenance personnel becomes diluted.

Cost of Transferring Unique Government-Owned Tooling/Equipment. If any unique government-owned tooling is difficult or expensive to transfer from one contractor to another, it may be necessary to provide duplicate sets of tooling in order for a second source to become a viable competitor. The cost of transferring tooling, then, can work in the same manner as the cost of the tooling itself in inhibiting the adaptation of the project to second sourcing.

Contractor Capacity. If the original producer does not have the ability to produce needed quantities of the system according to the required delivery schedule, development of a second source may become mandatory. Lack of adequate capacity may thus be considered a controlling factor in deciding for second sourcing. If, on the other hand, the original producer has sufficient or even excess capacity, reduction in the production quantities awarded may significantly increase the costs of production through increased overhead.

Production Lead Time. The longer the producton lead time, the longer it will take to bring a second source on line and the less appealing becomes the second sourcing option.

Contractual Complexity. The more complex the original production contract (e.g., Life Cycle Cost parameters, Design to Cost considerations, Warranty Agreements) the less adaptable to second sourcing the project becomes. With warranties, for instance, it may be necessary to keep two sources capable of performing warranty work throughout the life of the project -- even though a production buy-out may have been exercised at some point in the acquisition.

Amount and Type of Subcontracting. If the number

of qualified subcontractors is limited and the degree of reliance on those subcontractors is necessarily heavy, the benefits to be realized through second sourcing are necessarily lessened.

THE MODEL

The SSMS shown on the following pages is heuristic in nature. Its objective is to provide a logical and systematic framework for evaluating the applicability of each of the competitive methods in light of the variables present in the acquisition situation. The end result of the evaluation process will (at best) be the selection of the optimal competitive technique. At worst, use of the model should serve to eliminate one or more techniques from further consideration. In that case, the decision situation will have been simplified and certain of the variables should emerge as being critical, thereby, suggesting the areas which need further investigation and/or consideration.

Format of the Model. It should be noted that the model is actually two models. The pre-production model (Appendix A) is for use by the Program Manager who is developing his overall acquisition strategy. In other words, the program second sourcing decision is being made at some point prior to Defense System Acquisition Review Council (DSARC) II. The post-production model (Appendix B) is for use by a Program Manager who is already in the production phase of the program and is considering the generation of a second source for part of all of the remaining life of the acquisition. It is necessary to differentiate between the two situations because the effectiveness factors assigned to each of the methods change significantly depending upon whether the second sourcing decision is being made early or late in the program's life cycle.

The SSMSM lists 14 decision variables vertically on the left. Each of these variables is divided into two or three categories (e.g., high-medium-low, yes-no) to allow the model to be tailored to the refinements of a given acquisition situation. Across the top of the model are listed the second sourcing methodologies. It should be noted that the five methods, (F^3, TDP, DL, LF, and CT) when placed in that order, represent a line of continuum with respect to the degree of cooperation and contact needed between the original developer and the second source. For example, second sourcing on the basis of F^3 or TDP involves no need for contact between the two contractors. At the other extreme is CT which represents a formal alliance between two or more contractors. Recognizing this relationship among the methods provides a better understanding of the way each method relates to the variables and to the other methods. Understanding this relationship may even lead to effective modification or hybridization of the techniques not previously considered.

Effectiveness Factors. The model rates the effectiveness of each of the methods with respect to each of the decision variables. A simple three point system of "+", "0", or "-" is used to denote whether a given method is particularly strong, neutral, or weak with respect to each of the variables. An "X" is used to denote a situation where the use of a given method is particularly inappropriate, or, to caution that particular care should be used in applying a given method in that situation. An "*", on the other hand, indicates that the method is particularly well suited to the situation under consideration.

The three point system is used because of the non-quantifiable nature of the model. A wider scale (-5 to +5, for example) would merely invite argument over the rankings assigned and would detract from the main purpose of the model. The primary value of the model is that it serves as a guide to the subjective decision process and that it gives recognition to the differences among the methods. It is not intended to provide an elaborate quantification scheme which removes the need for experience and judgment.

DISCUSSION OF THE MODEL'S WEIGHTINGS

Quantity. Low production quantities make successful second sourcing difficult, at best. None of the methods will work well under such circumstances. By the time the second source is qualified as a producer, the savings potential on the remaining quantities will probably not justify the associated expense. In the post-production phase, the difficulties usually associated with the qualification of a second source through the use of a TDP make that method especially undesirable; whereas, the relative simplicity of the F^3 technique yields the greatest probability of success when low quantities are involved. Only where the magnitude of the system and its price are truly significant will small quantities justify the use of the DL, LF, or CT methods. As quantities rise, the viability of all the methods increases. Because there is a dilution of the total quantities to be produced subsequent to initial production, the pre-production portion of the model appears slightly more favorable than the post-production portion with respect to quantity.

Duration of Production. The rationale provided in the discussion on quantity also pertains to the duration of production variable. Any attempt to qualify a second production source will take time, and the likelihood of success decreases as the time required for the qualification of a second source increases. DL and LF techniques are therefore especially unsuitable since both assume original production by the development contractor.

Slope of the Learning Curve. If the demonstrated learning curve of the original producer is flat, all methods are worthy of consideration. Where steep learning is exhibited, the original producer will experience a significant competitive advantage for future awards; and, if cost savings is the object of the second sourcing effort, it may be extremely difficult to justify going to an alternate source. It should be noted, however, that a steep learning curve might also indicate that the base price was unrealistically high in the first place -- resulting in an unjustifiably inflated original award.

Technical Complexity. DL, LF, and CT are techniques that are designed to provide the necessary liaison and cooperation to assure effective transfer of even highly complex technology. CT is especially effective under such circumstances since the teams can be constituted such that complementary technologies can be brought together. When production by an original source has begun, CT, in the pure sense is not possible, however, a team of competitors might be attracted to vie for follow-on production contracts. Problems with TDP's are often insurmountable without costly and labor intensive effort when high levels of technology are involved. It is not impossible to use this method in such cases, however, extreme care must be exercised to ensure the adequacy of the data package and to ensure the choice of a second source which is likely to be capable of overcoming data package problems. The more simple the system, the more probable becomes the success of all the methods.

State-of-the-Art. The same rationale provided for the technical complexity factor applies to the state-of-the-art variable. The more liaison between the production sources, the greater is the chance of successful technology transfer -- transfer of state-of-the-art technology by data packages alone is virtually impossible.

Other Government and Commercial Applications. Where there are expected to be significant alternative uses for the system, the original producer may be expected to claim or generate legal or quasi-legal barriers (patents, trade secrets, proprietary data) to the dissemination of his design unless he is handsomely compensated or is given specific protection in the form of limitations placed on the use of his design. DL provides royalty payments to the developer/original producer; F^3 does not require the transfer of data; and CT arrangements specify that both members of the team will be capable of producing the end item so these methods facilitate the award of alternate follow-on production contracts. With a TDP, the post-production use of the method is less attractive since the original producer will usually have proof of alternative uses rather than conjectured alternatives.

Degree of Privately Funded R&D. If the contractor's privately funded R&D led to the development of a design that the government selects for production, it is almost certain that a significant amount of proprietary data will be included in the design package. In such a circumstance, he is likely to vehemently resist any attempt to disseminate that information. With DL and CT methodologies his rights will be protected or he will receive compensation for the use of his data so his resistance will be somewhat less violent. Although it is difficult to imagine a situation wherein all the R&D would be privately funded, the existence of a single critical process that is truly proprietary will greatly lessen the chance of second sourcing success.

Special Tooling Costs. When the cost of special tooling is significant, the willingness of potential competitors to enter the market -- without provision of government-owned tooling or unless the quantity and duration of production is sufficient to allow amortization of the costs of such tooling -- is limited. Regardless, the original producer will have a real competitive advantage where high tooling costs are included. Even where the tooling is government-owned, the potential disruption associated with the transfer of the tooling may be unacceptable -- requiring duplicate tooling to be provided. A contractor teaming arrangement, subsequent to initial production, might result in the need for three separate sets of tooling -- making such an arrangement particularly unpalatable.

Cost of Transferring Unique Government-Owned Tooling. Shifting of production units from one source to another implies one of two alternatives: (1) shifting the government-owned tooling, or (2) providing additional -- perhaps excess -- capacity in the form of duplicate tooling and equipment. Of course, where mobilization base considerations are controlling, the latter is mandated. Also, where the cost of buying duplicate tooling is less than, or equal to, the cost of transferring the tooling from year to year (including disruption costs), this variable may be eliminated from consideration. Since the cost of transferring tooling and equipment has an equivocal affect on all methodologies, the weighting assigned to each is identical.

Capacity of the Developer/Original Producer. When the original producer does not have sufficient capacity to allow him to manufacture the desired systems in required quantities, at required quality and to deliver those systems in accordance with the prescribed schedule, any of the methods may be considered. Where sufficient or excess capacity exists with the original producer, it may be more costly (especially in the short run) to second source than it is to remain with the original source alone. Cutting the quantities awarded to a source, with existing excess capacity, usually means that the fixed overhead must still be spread over the now lower quantities -- yielding higher prices.

Maintenance Requirements. Where field level maintenance needs are relatively insignificant, second source production presents little or no problem. As the need for field maintenance increases, however, the nonidentical nature of second sourced systems becomes more difficult to accommodate. F^3 systems usually exhibit the least degree of commonality and therefore cause the most severe maintenance and support problems.

Production Lead Time. The longer the lead time associated with the production of the system, the more difficult it becomes to bring alternative producers on line early enough to realize the potential advantages of second sourcing. This holds true regardless of the second sourcing method chosen.

Contractual Complexity. The more complex the

contractual relationship between the original producer and the government, the greater are the barriers to successful second sourcing. Life Cycle Cost parameters, Reliability Improvement Warranties and other contractual complexities become difficult to enforce when dealing with multiple sources. In fact, the cost of maintaining multiple source warranties may become prohibitive.

Degree of Subcontracting. Where there is a great deal of subcontracting or where the number of firms capable of performing subcontracting functions is limited, the advantages of second sourcing the prime contract will be diluted. Given the fact that the primes may be forced to compete for the services of the same subcontractors, or use the materials of a single supplier, the prices may even rise with second sourcing.

USE OF THE MODEL

As stated earlier, the model is not designed to be a strictly quantified decision-making device wherein the evaluation factors for each method are summed and the method with the highest "score" is selected. The correct use of the model requires the use of judgment at every step. The first (and possibly most difficult) step is to evaluate the acquisition situation in terms of the decision variables (that is, to determine whether the acquisition will cover high, medium, or low quantities; whether technical complexity is high, medium or low; and to make similar judgments about the other variables). The Program Manager is encouraged to add new variables to the list as he sees the need for them. The next step is to evaluate the second sourcing methods in relation to the variables which exist in a program -- realizing that some variables will be more important than others. One method may turn out to dominate all the others or there may be more than one feasible method. Additional judgment will, therefore, be required. It may even be possible to allow the competing contractors to have an input to the decision process. If the model can simplify and guide the thought process so that: (1) all significant variables are recognized and objectively evaluated, (2) clearly inappropriate second sourcing strategies are eliminated, and (3) an appropriate method is selected, then the model will have served its purpose.

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SECOND SOURCING METHOD SELECTION MODEL (PRE-PRODUCTION)

Variables		Methodology				
		F^3	TDP	DL	LF	CT
Quantity	High	+	+	+	+	+
	Medium	+	+	0	0	+
	Low	0	0	–	–	0
Duration	Long	+	+	+	+	+
	Medium	+	+	0	+	+
	Short	0	0	X	X	0
Learning Curve	Steep	–	–	–	0	0
	Flat	+	+	+	+	+
Technical Complexity	High	0	X	+	+	*
	Medium	+	–	+	+	+
	Low	+	+	+	+	+
State of the Art?	Yes	0	X	+	+	*
	No	+	+	+	+	+
Other Application	Yes	+	0	+	0	+
	No	+	+	+	+	+
Degree of Private R&D	High	0	X	0	X	–
	Low	+	0	+	+	+
Tooling Costs	High	–	–	–	–	X
	Low	+	+	+	+	+
Govt. Tool Transfer Cost	High	0	0	0	0	0
	Low	+	+	+	+	+
Contractor Capacity	Excess	–	–	–	–	–
	Deficient	+	+	+	+	+
Maintenance Requirement	Significant	X	0	0	0	0
	Minimal	+	+	+	+	+
Production Lead Time	Long	–	–	–	–	–
	Short	+	+	+	+	+
Degree of Subcontracting	Heavy	0	–	–	–	–
	Light	+	+	+	+	+
Contractual Complexity	Complex	–	–	–	–	–
	Simple	+	+	+	+	+

APPENDIX (A)

SECOND SOURCING METHOD SELECTION MODEL
(POST-PRODUCTION)

Variables		Methodology F^3	TDP	DL	LF	CT
Quantity	High	+	+	+	+	+
	Medium	+	0	0	0	0
	Low	0	X	-	-	-
Duration	Long	+	+	+	+	+
	Medium	+	0	0	0	0
	Short	0	X	X	X	-
Learning Curve	Steep	0	0	0	0	0
	Flat	+	+	+	+	+
Technical Complexity	High	0	X	+	+	+
	Medium	+	-	+	+	+
	Low	+	+	+	+	+
State of the Art?	Yes	0	X	+	+	*
	No	+	+	+	+	+
Other Application	Yes	+	-	+	0	+
	No	+	0	+	+	+
Degree of Private R&D	High	0	X	0	X	0
	Low	+	0	+	+	+
Tooling Costs	High	-	-	-	-	X
	Low	+	+	+	+	+
Govt. Tool Transfer Cost	High	0	0	0	0	0
	Low	+	+	+	+	+
Contractor Capacity	Excess	-	-	-	-	-
	Deficient	+	+	+	+	+
Maintenance Requirement	Significant	X	0	0	0	0
	Minimal	+	+	+	+	+
Production Lead Time	Long	-	-	-	-	-
	Short	+	+	+	+	+
Degree of Subcontracting	Heavy	0	-	-	-	-
	Light	+	+	+	+	+
Contractual Complexity	Complex	-	-	-	-	-
	Simple	+	+	+	+	+

APPENDIX (B)

Use of Fixed Price Incentive/Award Fee Contracts for the Construction of Follow U.S. Navy Ships.

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This paper reports on research conducted to find an optimum contract for use in the acquisition of follow ships for the Navy. The paper starts with a look at problems experienced by the Navy when using FPI contracts for ship acquisition and analyses the general needs of a follow ship contract. Next, the Fixed-Price-Incentive/Award Fee (FPI/AF) approach is described as are the benefits derived from this new type of contract. Finally, other applications and variants of the FPI/AF approach are reviewed.

BACKGROUND

In the late 1960's and early 1970's the Navy moved to the use of Fixed-Price Incentive (FPI) type contracts for the design and construction of lead and follow ships. It was intended that a comfortable target to ceiling spread would provide for cost growth risk associated with these contracts. The largest of the FPI contracts was awarded for the thirty ship DD 963 buy and for the nine (later reduced to five) ships of the LHA class. Both of those contracts were valued at more than a billion dollars each.

Soon after award of those and other early 1970 FPI ship construction contracts, cost growth and delivery delay problems surfaced. A number of factors contributed to the cost growth and delays, but more importantly, the inability of the parties to fix price lead and first follow ship buys was brought into focus. Labor hours were difficult to project as was learning associated with those hours. Even though escalation features dampered the effects of direct labor and material cost increases, the basic material estimates were weak because the detail design of the ships had not been accomplished at the time of contract pricing. Other unknown factors such as design conflicts and the effects on schedule of Government Furnished Equipment (GFE) and related Government Furnished Information (GFI) also made fixed pricing difficult. Most of the FPI ship acquisition contracts experienced heavy formal and informal changes, which influenced cost growth and disputes.

Another problem associated with FPI ship construction contracts is the fact that cost is not an incentive until later in the contract, when the Contractor can see cost performance as it relates to target and ceiling price and the Point of Total Assumption (PTA), a point at which further cost growth reduces contract profit to a point where profit disappears. In an FPI application, there is no positive reason for the Contractor to look at those elements that effect his target profit early in the contract, since the effects of those influences on target profit don't come into play until much later in the life of the contract. Also, if the Contractor loses cost control early in the contract, there is no reason for him to attempt to regain control of cost later, since he can never improve his target profit. Once cost control is lost, the main objective of the Contractor is to determine how he can recover perceived or actual losses through changes or claims, or to determine how to hold his losses to a minimum. At this point, the concept of improving target profit by cost control is lost forever.

In the mid 1970's, because of the problems mentioned above, the Navy moved to the use of Cost-Plus-Incentive-Fee (CPIF) contracts for lead and early follow ships. The FFG-7 Program is one example. Use of a cost type contract did improve the Navy's business relations with the shipbuilder since the Navy assumed a larger share of the risk associated with the new acquisitions. Although the FFG-7 contracts have proven to be successful, it became obvious in the late 1970's that some of the FPI contract problems can be carried forward to CPIF contracts. The same two-fold problem is that (1) cost only incentives don't come into influence until later in the life of the contract when

the contractor measures his expected performance to target cost and (2) if cost control is lost early in the contract, there is no further interest by the Contractor in renewed cost control since (a) his costs will be covered and (b) he can no longer influence target profit.

The perceived weakness of CPIF contracts plus the desire of Project Managers to encourage superior shipbuilding contract performance lead the Navy to utilize Cost-Plus-Award-Fee (CPAF) type contracts for the design and construction of DDG-47 and 48. By using carefully structured award fee provisions the Navy has been able to motivate the shipbuilder in technical,schedule management cost performance areas, with a pre-determined pool of award fee dollars applied throughout the period of the contract. The distinct advantage here is that, even if the contractor has early cost and schedule problems, he can still earn award fee profit later in the contract period by superior performance. The Contractor is motivated each quarter to again perform in a superior manner and achieve award fee dollars as a result of that superior performance.

The problem of a viable contract for the purchase of follow ships still exists. Since reliable cost information is available, continued use of cost type contracts is not necessary. However, the old problem with the FPI contract for follow ships returns and another type of fixed price contract needs to be developed if the Navy hopes to continue to motivate the Contractor to superior, across-the-board performance.

NEEDS OF A FOLLOW SHIP CONTRACT

This section of the paper will address the specific needs of a follow ship contract. They are cost control, timely delivery, high quality performance, and management attention. Each of these needs will be addressed separately.

Cost control is an important consideration is any contract, but especially important in one for a follow ship for a number of reasons. First, the contractor may be switching from a cost type contract for the lead ship to a fixed price instrument for the follow ship. Tighter cost control must be established than on the lead ship. Even with a healthy target to ceiling spread, the contractor will only receive X dollars from the government for the construction of the ship. There is also a need to establish cost control early, as has been learned in cost type contracts. If cost control is not established early, the chances of achieving effective total cost control is minimal.

Another reason for cost control on follow ships relates to the fact that the lead ship is usually a "show" ship, on which the contractor keeps the cost down in hopes that follow ships will be funded by Congress and awarded to his yard. Once the lead ship is delivered at or near target cost, there may be a tendency by the contractor to "ease up" on cost control, since his initial objectives have been accomplished and the follow ship has been assigned/awarded to his yard. This "ease up" tendency is doubly dangerous since the contractor is now in a fixed-price setting.

Cost is also something that Congress watches closely. They are concerned about "buy-in's" and therefore watch early follow ships to relate actual cost to the budgeted and appropriated dollars. Unfortunately, inflation and economic adjustment (escalation) clauses cloud what Congress can discern. If, however, follow ship costs blossom above projections, the balance of the follow ships may be killed by Congress.

Finally, control of follow ship costs are important because the Navy and shipbuilders must avoid the claims mentality that plagued shipbuilding in the 1970's. If shipbuilders lose control of the cost of fixed price follow ships, they may feel that their only recourse is adversarial relationships that result in large claims and late delivery of critically needed ships. Historically, early cost control predicates total contract cost control and reduces the probability of the contractor suffering losses in the performance of follow ship contracts.

The second important need in a follow ship contract is to encourage the contractor to achieve timely delivery. Again, because the contractor is normally switching to a fixed-price contract for a follow ship, he will be working the ship in a most economical manner, which could have an adverse effect on the ships contract delivery date. Remember that the Navy does not tell the contractor how to build a ship, especially when the contractor has to achieve a fixed-price performance. However, there should be some way that the Navy can encourage the contractor to achieve contract delivery date, while also controlling costs. A real delivery impediment is the fact that follow ships are normally allowed less time between start of fabrication and delivery. This means that the contractor has to improve on the production schedule achieved on the lead ship, while probably <u>reducing</u> target cost. (Reduction in target cost is expected because of labor learning and other economies of scale.) In order to achieve this shorter production schedule, the contractor will have to religiously meet major fabrication, assembly and erection milestones, especially early milestones. If the contractor can be encouraged to meet these early production milestones, there is a higher probability that he can achieve contract delivery date.

Another dysfunction to the timely delivery of a follow ship is the fact that the lead or "show" ship will probably be delivered as the follow ship reaches its peak manning level. If there are problems in finishing the lead ship, the contractor may use many of his best people to assure that the lead ship finishes on time. This is sometimes called "crashing" a ship. The obvious side effects of crashing is that key work on the follow ship can be delayed.

Finally, people problems are associated with late delivery of a follow ship. Crews may be going through a twelve to sixteen month training pipeline in order to meet the ship immediately prior to or at ship delivery. These men may have been away from their homes and families for from six to twelve months. To ask them to wait around the builders yard for another six to twelve months may encourage them to seriously consider another line of work.

The question remains: how do you motivate the contractor to achieve timely delivery of a follow ship and avoid the many problems associated with late ship delivery?

The third important follow ship need is high quality. It would be meaningless to deliver a ship on time, within target cost but unable to meet its operational requirements because the ship was not built well. Quality and performance problems are usually associated with a lead ship, because the bugs have to be worked out of a "first a of a kind." However, if the contractor is only motivated by cost or is motivated only by cost and schedule incentives, the government may be encouraging the contractor to give quality short shift. Another aspect of quality, like cost and schedule, is that the lead ship is the "show" ship and the contractor will attempt to produce that ship to a high quality standard. Will the contractor ease off on quality efforts on the follow ship, especially in a fixed price environment? Somehow the contractor has to be encouraged to maintain or even improve quality on the follow ship. Actually, the government should expect improved quality since the contractor should be applying lessons learned during the construction of the lead ship. Again, important quality levels in a follow ship are being reached about the time the lead ship is being delivered. If good Quality Assurance people are pulled off the follow ship to assure the delivery of a good lead ship, the quality of the followship could suffer. In that same regard, the contractor may concentrate most of his talented craftsmen on the lead ship and assign less qualified journeymen and apprentices to the follow ship. How can a contractor be encouraged to maintain a good mix of talent on both the lead and the follow ship?

The final follow ship need is the obvious need for the contractor to effectively manage his work effort. Historically, poorly managed ship construction programs have experienced cost growth and delivery problems. In one major ship program, the contractor assigned five different program managers over a five year period. That program still holds the world record for delivery delay and cost growth. A subset of this kind of problem occurs when the contractor overmanages the lead "show" ship, but assigns weaker management to follow ships. Why can't the contractor maintain aggressive management on the follow ship?

As mentioned earlier, the problem of turnover is critical. If the contractor assembled an effective management team for the construction of the lead ship, he should leave that team in place for the follow ship. Some of the management functions that tend to slip in the production of a follow ship are material management, configuration management, data management and control of changes. Unless the contractor is encouraged to keep changes on the follow ship to a minimum, he may see follow ship changes as a way to "get well" in a fixed price setting. Traditionally, many changes result in cost growth and delivery delay. In management performance, the key word may be attitude. An attitude that makes things happen on the lead ship can make the same things happen on the follow ship.

In summary, the needs of a follow ship contract are to encourage the contractor to meet or reduce his target cost while delivering a high quality ship on or before the contract delivery date. How can these needs be met? The next section of this paper describes how a FPI/AF type contract can motivate a contractor in a follow ship setting.

A NEW APPROACH - FPI/AF

The new approach proposed is actually a combination of a Fixed-Price-Incentive (FPI) and a Cost-Plus-Award-Fee (CPAF) contract. The basic structure of the contract is fixed price incentive with incentive features for cost only. However, interwoven into the contract are award fee features which encourage the contractor to provide superior technical, schedule, management and cost performance.

In technical performance, such basic ship construction factors as design and construction performance, test and trials, reliability and maintainability and ship characteristics are measured.

In schedule performance, the accepted DODI 7000.2 schedule factors are measured. Also, milestone performance and the contractor's efforts in early schedule problem identification and correction are judged.

In the area of management performance, factors such as MIS, program management, contract management, procurement management, material management, configuration control, data management and personnel management are reviewed.

Cost factors which are monitored include basic cost performance and early cost problem identification and correction.

The mechanics of FPI/AF are straighforward. The contract has a normal target profit and target to ceiling spread. As an example, a follow ship FPI/AF contract could have a target cost of $400 million and a target to ceiling spread of 125% or a ceiling price of $500 million. If a contract profit objective of about 15% or $60 million was desired, 3% or $12 million could be assigned to the basic FPI portion and 12% or $48 million to the award fee portion of the contract. Note that the 3% FPI profit is not base fee in an award fee sense. Consider that the award fee portion of the contract has a zero base fee and a 12% award fee, therefore the contractor can earn between zero and 12% based on his peformance. Since a normal follow ship contract has a life of about 20 quarters, you can see that feasible award fee profit can amount to two million dollars a quarter (and paid at that time). In fact, good planning dictates that a greater portion of the award fee should be earnable in the first half of the contract life because experience shows that if a ship is on schedule at midpoint in construction, it has a high probability of finishing on time, while a ship that is behind schedule at midpoint will normally deliver late. The first consideration, then, is how to distribute the pool of award fee dollars over the life of the contract. In the example above, assume that $30 million is assigned to award fee profit for the first 10 quarters of the contract and $18 million to the last 10 quarters of the contract.

The second consideration is the split of award fee within an applicable quarter to the technical, schedule, management and cost categories. A logical approach is to consider the type of performance that is important in a particular quarter, like Quarter 1 or Quarter 5, and to distribute the award fee selectively within any quarter. For instance, in the first quarter, technical and management performance may be key and receive all of the award fee distribution. (Quarter 1 might be Technical 50%, Schedule 0%, Management 50% and Cost 0%). Later in the contract, like in Quarter 10, schedule and cost may be most important, but management and technical performance may retain a minor role. (Quarter 18 might be Technical 15%, Schedule 35%, Management 15% and Cost 35%).

In any regard, the modus operandi would be for the government to propose an award fee pool table, with an award fee spread for the four performance categories during the life of the contract. The contractor, on the other hand, is allowed to propose other measurement factors and rationale for a different award fee pool and distribution. The exact makeup of the categories and factors to be measured and the composition of the award fee pool would be the subject of final contract negotiations.

In operation, after award, the contractor would be graded periodically (usually quarterly) by a team headed by the government's Program Manager. If desired, a Reviewing Authority can be established to make a final award fee recommendation to the Contracting Officer. The contractor may be allowed to reclama his designated award fee amount, but the decision of the Contracting Officer is final and not subject to the Disputes Clause found in the contract. The grading by the government is subjective and pertains to how the contractor's performance relates to the requirements of the contract. For instance, performance that exceeds contract requirements may be judged excellent. Each of the four performance categories are normally graded and an adjective rating, like "excellent", relates to a numerical percentage, which is applied to a simple formula to determine the award fee profit that the contractor will receive that quarter.

A separate contract modification is issued as a result of the grading process and the contractor is paid earned award fee immediately.

Because of the mixed fixed price and award fee nature of a FPI/AF contract, some of the contract general clauses have to be revised to allow for normal contract operations. Clauses that require revision are (1) Incentive Price Revision (Firm Target), (2) Compensation (3) Payments and (4) Changes. New clauses include Award Fee and Determination of Award Fee in Event of Termination. The changes in the usual clauses allow for award fee to be paid in addition to normal contract progress payments and to provide for a way to handle award fee profit so that it will not impact target profit nor ceiling price.

In summary, the new FPI/AF approach provides the ability to motivate the contractor to superior technical, schedule, management and cost performance in a fixed-price setting. This is done by providing a target profit <u>and</u> an award fee that is based on subjective quarterly grading of the contractor. Award fee profit is paid throughout the life of the contract, with a greater percentage earnable in the first half of the contract period to encourage timely contract performance. The award fee payable each quarter is further divided to provide an incentive for superior performance in particular categories. The subjective grading methodology uses a relatively simple formula to determine the exact award fee to be paid each quarter. Unearned fee in any quarter

is not shifted to later quarters. An FPI/AF contract requires some revision of basic contract clauses to provide for countervailing fixed price and award fee features.

BENEFITS OF FPI/AF FOR FOLLOW SHIP ACQUISITION

The first recognized benefit of FPI/AF is improved cost control. Cost control is encouraged early through the heavy application of award fee dollars in the beginning quarters of the contract. Also, in the approach, temporary loss of cost control is not fatal and the contractor is financially encouraged to regain control of costs as soon as possible. The FPI/AF approach also motivates early identification of cost problems. The contractor can compare monthly the actual cost of a work package versus the budgeted cost and determine the cause of an overrun in an individual package, possibly precluding further similiar overruns downstream. A secondary but dollarwise impressive cost benefit of FPI/AF is that escalation dollars paid to the contractor can be reduced by achieving target cost and contract delivery date. Escalation clauses provide protection from unusual labor and material inflation experienced during a long-term, fixed price contract. For a $400 million ship contract with a five year life, escalation could amount to $200 million or more. Since escalation payments are a function of actual dollar cost and time, control of cost also means control of escalation dollars. As an example, in a contract with a target cost of $400 million and a ceiling price of $500 million, cost growth to ceiling ($500 million) could mean an additional $50 million in escalation payments.

Another major benefit of FPI/AF is the attainment of delivery schedule. Heavy application of award fee dollars early in the contract encourages early attention to schedule. As mentioned earlier, ships that are on schedule at midpoint in construction usually finish on time. The FPI/AF approach also motivates the contractor to recover from schedule problems which are caused either by his organization or by the government. Sometimes a shipbuilder is delayed by the late delivery of government furnished information or equipment. With FPI/AF, the contractor can be rewarded for recovering his schedule in spite of major setbacks.

Early identification of schedule problems is also driven by FPI/AF features. The contractor can check the actual time it took him to complete a discrete work package against the budgeted time. Problems identified can be avoided in similiar work packages downstream.

As with cost control, schedule control can alleviate sizeable escalation payments in a follow ship contract. Escalation payments are heavily influenced by time, especially because our country's inflation rate has been severe in recent years. Using our example of a $400 million follow ship contract with a five year life, schedule growth of twelve months could increase escalation payments by $50 million or more, not counting the increased escalation payments resulting from probable cost growth. On the other hand, delivering the follow ship six months early could save up to $25 million in escalation payments. Finally, as mentioned earlier, achievement of scheduled delivery date could alleviate a whole series of personnel problems for the crew.

A third benefit from the use of FPI/AF in follow ship acquisitions is the delivery of technically superior ships. The U.S. Navy is having severe maintenance difficulties with older ships and does not need the problem of heavy maintenance workload on new ships, which unfortunately has been the case in recent years. High technical performance should produce a ship that is both reliable and maintainable. Also integrated logistic support should be improved on the follow ships, with start-up problems resolved. In theory, fewer technical problems in follow ship should make delivery easier, thereby reducing the possibility of delivery delay and resultant cost growth.

The final benefit of FPI/AF is that it encourages management attention to the performance of the contract. Generally, moderate or heavy contractor interest in a contract assures that all types of problems do not go unnoticed or unresolved. For one thing, good management would insure that DOD Instruction 7000.2 is implemented on the follow ship, which should support vigorous cost and schedule control. Also, good management would dictate that the contractor's lead ship team stay together to work the follow ships. Lessons learned by that team can be executed in the follow ships, which should improve technical, schedule and cost performance. Configuation control by management on the follow ships should contribute to better technical performance. The same benefit applies to the control of changes, which could help the ship technically and discourage cost and schedule growth. Experience has shown that a large number of changes in a follow ship usually results in both cost growth and delivery delay.

In summary, the benefits of a Fixed-Price-Incentive/Award Fee (FPI/AF) contract for a follow ship are related to encouraging the contractor to deliver a good ship on schedule within target cost. The award fee features encourage the contractor to tackle his cost and schedule problems early and to apply an effective management team to the contract. The major secondary benefit relates to the avoidance of expensive escalation payments that result from cost and schedule growth.

OTHER APPLICATIONS AND VARIANTS

This part of the paper will look at other applications and variants of a Fixed-Price Incentive/Award Fee (FPI/AF) type of contract. The paper will speak to applications and variants separately.

One of the most obvious uses of FPI/AF would be for procurement of the balance of the follow ships in a Class. If more than one builder were utilized, FPI/AF could be used to encourage the follow builders to keep the Class identical, as well as on schedule and within target cost. In any regard, a FPI/AF contract should be more effective than the straight FPI instruments now being awarded. FPI/AF could also be used for other weapon systems. The Naval Air System Command has already used Cost-Plus-Award-Fee (CPAF) for aircraft and FPI/AF might be tailored for follow on procurements of aircraft and other large systems like missiles and vehicles.

FPI/AF could be used in problemsome ship overhaul contracts. Presently fixed-price contracts are awarded for overhauls based on Navy Master Ship Repair Contracts and utilize competitive bids. One experiment has begun in Seattle wherein award fee provisions are being used to motivate the contractor to a normal fixed-price overhaul contract. The Navy is experimenting with Cost-Plus-Fixed-Fee (CPFF) and Cost-Plus-Award-Fee (CPAF) for large overhaul contracts, but FPI/AF could be utilized where work scope is sufficiently clear. It may also be possible to use FPI/AF provisions in fixed-price service contracts, where superior contract performance is very important to the government. An example could be food service contracts where good service is important to the health and morale of the servicemen involved.

Variants of Fixed-Price-Incentives/Award Fee (FPI/AF) are easier to discuss than to develop. For instance, it may appear easy to use straight Fixed-Price Award-Fee (FPAF) applications for follow ship buys, but target to ceiling spread or other methods of handling unplanned cost growth are difficult to structure with straight FPAF. Once cost history is firmly established in a ship Class, it could be possible to use straight FPAF as long as economic adjustment clauses are used. Looking at more difficult variants, FPAF awarded from Invitation for Bids (IFB's) could be possible. While IFB's are not normally used for major system buys, it would still be worthwhile to motivate a contractor with award fee provisons in IFB related fixed-price instruments. A final idea for FPI/AF could be the use of this approach in tandum with a CPAF contract. Consider the situation of an early follow ship, where cost experience will not allow use of a fixed-price contract. In this case, it may be feasible to start the early follow ship with a CPAF contract and then convert to a FPI/AF or FPAF midway (about two and half years) into the contract. The Naval Sea Systems command is considering such a contract. Any type of convertible contract is difficult because the parties may be unable to agree on the terms and conditions of the second-part contract, but conceptually they are interesting.

In summary, there could be many applications for and variants to the Fixed-Price Incentive/Award Fee contract approach in weapon system acquisition. It is recommended that graduate students and other procurement researchers look in detail at such applications and variants as a necessary step in broadening the state-of-the-art in contracting for our important weapon systems of the future.

AWARD FEE CONTRACTING APPLICATIONS IN THE U.S. AIR FORCE SYSTEMS COMMAND

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ABSTRACT

Conducted under auspices of the Air Force Business Research Management Center at Wright-Patterson Air Force Base, this study had three objectives: (1) to clarify the conceptual basis of award fee contracting methods; (2) to describe empirically their application in Air Force Systems Command (AFSC) programs; and (3) to identify lessons which could be learned about the award fee method from these applications. This paper partially summarizes mainly the results of the research in relation to the second of these objectives.

METHOD

From previous research and existing literature, a "theory" of the award fee approach to acquisition was formulated as a guide to empirical description and analysis of its use in actual cases. The theory presents the award fee as a distinctive management tool for planning and controlling performance in contracted system acquisition.

Fifteen applications of the award fee contracting method in the AFSC were selected as cases for study. The cases studied were chosen to represent a variety of kinds of work, programs of differing sizes, contracts of varying types, and contract fee structures in which the award fee varied as a proportion of total fee.

For each case, a detailed review was done of its Evaluation and Fee Determination Plans and of the methods by which those plans were implemented. This was accomplished mainly by examination of documents and files and by interviews with some 35 government and 16 contractor personnel. From these reviews, empirical descriptions of patterns of award fee application were generated and analyzed for consistency with award fee theory.

Interviews with both government and contractor personnel dealt with their experiences in relation to the award fee provision of the programs studied, and their judgments about them. These interviews provided insight into conceptualizations of the award fee among contractor and government people and a view of their subjective responses to it. These data were analyzed in relation both to particular features of the specific programs studied, and also more generally in relation to award fee theory.

Thus, by extending analyses of case data to include tripartite relations between theory, empirical patterns of award fee applications, and the beliefs about, experiences with, and reactions to them by government and contractor managers, an "input evaluation" of the award fee approach to acquisition was accomplished. This evaluation provides an effective basis for identifying policy and technical recommendations for more effective use of the award fee method in system acquisition, and for identifying award fee-related research needs.

RESULTS

An AFSC Award Fee Scenario. Empirically, patterns of award fee applications in the AFSC generally stay within traditional bounds. Undertaken from a perspective stressing contractor compensation more than program management, award fee is mostly viewed simply as an alternative contract-type, intermediate between CPIF and CPFF. (1)

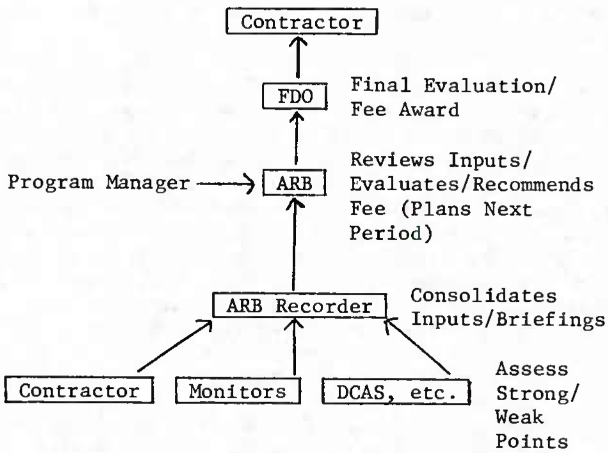
Evaluation plans for AFSC award fee applications, while variable in detail, commonly identify two or three levels of performance factors on which to base contractor evaluation. Factors normally are weighted for importance and orient to output rather than input (or process). Concern about subjectivity in award fee evaluation regularly stimulates attempts at "objectification" of evaluation standards and procedures.

AFSC policy seeks to establish award fee organization "at the lowest practical level." Unless otherwise mandated by higher Air Force authority, typically an officer below the commander of the Air Force buying Division will act as Fee Determining Official (FDO). Award Review Boards (ARB) are likely to be chaired by a Deputy for a buying organization within the Division or by an SPO Director, Program Manager, or other comparable officer, depending on circumstances. Some tendency to standardize award fee organization exists, but variability continues. Standardized or not the ARB is managerially the most important unit of the AFSC award fee organization. It plans, conducts, and manages contractor performance evaluations, and recommends fee awards to the FDO. In doing so, an ARB ordinarily makes use of project officers as monitors and evaluators of task-level contractor

performance, and a "recorder" to coordinate and document these processes.

The government Program Manager (PM) may be, but often is not, a literal member of the award fee organization. In any case, he or she plays a principal role in award fee planning, evaluation, and fee determination, as well as in overall program control. He or she normally selects, assigns, and supervises monitors, and the PM's briefings and recommendations usually are decisive in the outcomes of deliberations by the ARB and FDO.

A typical award fee evaluation can be diagrammed as follows:



Contractor input to the ARB/FDO may be via direct formal self-evaluation and/or briefing, or indirect, via the PM.

Grading systems for contractor performance evaluation vary considerably throughout the AFSC. Mostly they involve adjective ratings ranging from "unsatisfactory" through "good" and "very good" to "excellent," with correlated percentage ratings (and color codes). The correspondence of adjectives and percentage ratings is no more than approximate across AFSC organizations, however, so that the meaning of "grades" there is variable.

The AFSC strives for at least quarterly award fee evaluations. Fee determining evaluations may be more widely spaced, however, and often coincide with milestone achievement.

Fee awards have been variable in AFSC programs, ranging from 0-100%, (usually additive to a two or three percent base fee). AFSC policy emphasizes payment of fee only for superior performance, but policy is not always followed. Policy also counsels against carrying unearned fee over for possible award in later periods; and it encourages allocating larger fractions of the award fee pool to later rather than earlier periods.

COMMENTARY

The preceding scenario, viewed in context with wider Air Force views and policies, and in relation to the published literature, practices elsewhere, and award fee theory, suggests several issues deserving of either or both policy review and research. (2) Briefly, they are these:

(1) Award fee evaluation and grading norms and practices in the AFSC are complicated, hard to understand, and excessively variable. They need to be simplified, clarified, and made to show more commonality, especially within program offices. Policy review of and guidance on these matters should consist not of prescriptions for detailed scoring systems, but of basic standards which every system is expected to satisfy. Policy standards should encompass: a. selection of performance factors; b. criteria for assessment; c. methods of measurement; d. provisions for weighting performance factors (or advice against it); and e. guidance regarding the definition of minimum acceptable performance levels.

(2) Alternative methods of providing contractor input to award fee planning and evaluation warrant careful review and probably empirical evaluation.

(3) The effects on award fee processes of different organization levels needs study to provide better guidance that is consistent with aspirations for decentralized decision-making and for policy-level program oversight.

(4) It rarely is possible for contractors to earn maximum award fee. All aspects of this issue need careful review. Consideration should be given to: a. relaxing prohibitions (where they exist) against carrying unearned fee forward to later evaluation periods; and b. employing a model for fee pay-out that would align it with the utilities of performance change for the government.

(5) Policies on allocating portions of the award fee pool by period need review in order to encourage greater discretion and tailoring of allocation plans to circumstances of particular acquisitions.

(6) There is uncertainty both about award fee objectives and Air Force policy regarding them. This warrants review and clarification of Air Force policy on the award fee and its use.

(7) To encourage imaginative application of award fee strategies to new acquisition problems, guidance on award fee concepts is needed more than it is on procedures.

Award fee contracting needs to remedy three major general defects and confront certain choices. The first defect is that award fee evaluation plans too often are egregiously overelaborate. "Simplicity" rules of thumb are routinely violated by excessively large numbers of evaluation factors and complex scoring methods, which even their users frequently cannot understand.

The second defect is related to the first one. It is this: award fee planning and administration typically suffer from "objectivist" biases which subvert the intended role of the award fee as a means of effecting subjective evaluations of con-

tractor performance, and may damp the communication essential to removal of equivocality from necessarily ambiguous work statements. They tend also to decrease the ability of government managers to control the programs for which they are responsible.

In addition, award fee contracting suffers from a third major problem: bureaucratization. The danger from standardization or bureaucratization is not the simple fact of it, but the ways it inhibits flexibility and discretion in environments (like R&D) where flexibility and discretion are essential to effective management.

Hence, the first choicepoint: there is need now to orient (or reorient) award fee contracting policy in the DOD and elsewhere to the basic trinity: simplicity, subjectivity, and flexibility. Training probably would be the soundest way of doing this. Further development of award fee contracting "manuals" probably would be the poorest way of doing it. Most, if not all, procedural questions work themselves out in a framework of sophisticated award fee application. The training which is needed is not in the procedural details of the award fee; these are familiar anyway. It is in basic concepts and strategic objectives, and especially the facilitative functions of award fee for program management in the "free enterprise arsenal." And so, a second choicepoint.

Most of the real problems of award fee practice come to rest at the program level. They translate there to management strategies and tactics. A capability for sophisticated program management is surely decisive for effective system acquisition. This, however, implies the fundamental precondition of "managerialist" rather than "contractualist" acquisition strategies, an orientation to which the government is not yet clearly committed.

Partly this is a matter of policy, with respect to which there are internal disharmonies as well as inconstancies between policy and operational environments. Whether or not to accept a joint government-contractor management model of system acquisition (3,4) as valid in the United States and to follow its methodological implications--via award fee techniques and otherwise--is, then, a final most critical choicepoint.

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FITTING THE CONTRACT TO THE ACQUISITION

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ABSTRACT

This article reports on research conducted during February and March, 1980 concerning the process and criteria used in selecting contract types for major acquisitions. The research extended into civilian and military agencies and contractor organizations. Statistical samples collected indicate that cost type contracts predominate in all of nine organizations sampled. The research also indicates that contract type decisions occur principally during planning, not negotiation phases of the contracting process. The research identified seventeen criteria pertinent to contract type decisions.

INTRODUCTION AND OBJECTIVES OF THE RESEARCH

The story of General Atomic's gas reactor project at St. Vrain, Colorado makes good after hours reading for frustrated project managers of high technology acquisitions. Management at General Atomic moved rapidly from their successful pilot reactor to construction of full scale power plants --and they fixed the sale price to their utility customers and guaranteed on-time delivery of power at specified cost levels. That was in 1967. By 1975 they had lost a billion dollars (1) Full scale operations haven't begun as yet.

General Atomic wasn't the first to learn that the contract is a powerful tool. All manner of business relationships are created using it. As an instrument for drawing together resources to perform work or as a means for exchange of assets, it stands alone in terms of its flexibility. It can be oral or written, in existence for only hours or for years. Its monetary value may range from insignificant amounts to billions of dollars. It can be created in moments or through days and months of interaction between the potential parties. While the tool itself is ubiquitous, each contract is unique with respect to its terms and conditions, its values, the parties, their objectives, and the outcome.

It is the purpose of this paper and the research upon which it is based, to examine contracts in relation to a limited set of circumstances; sponsorship of undertakings where the contract directly finances performance of work, not simply transfer of existing goods, over extended periods of time and for substantial amounts of effort and dollars. The primary focus is government purchase of research, research and development, production, major systems, and/or services.

Particular concerns to be addressed in the paper are: a) the criteria upon which decisions respecting contract types are made; b) the processes by which decisions are made including the roles and influences of participants in the process, and c) the relationship between the contract (its terms and conditions) and project outcome.

While any contract is made up of numerous provisions, including ones that address technical, schedule, acceptance and payment agreements, this paper seeks to address those provisions which establish what is commonly referred to as "contract type." They have particular importance because, to a large degree, they allocate risks respecting the outcome between the parties, and they define the level of responsibility and accountability for performance of the effort embraced by the contract. These provisions address the circumstances under which payment is to be made and in many cases will treat entitlement to profit and cost payments as distinguishable sums.

METHOD OF STUDY

Research for this paper was performed during February and March, 1980 in Washington, D.C. The principal technique employed was personal interview using an unstructured interview during which the interviewer suggested particular topics, asking the interviewee to express personal experiences, perceptions and opinions. The interviews were recorded, and this paper is a digest and analysis of the findings. Background for the interview sessions was developed through review of pertinent regulatory sources, articles, theses, professional texts and business services designed for practitioners in the field. In addition, the author has extensive experience in

contract negotiation and as a teacher in the field. Interviews were conducted on a non-attribution basis. However, the interview data was drawn from experienced top level managers in the acquisitions field at civilian and defense agencies of the government and with private contractors. In addition, selected statistical summaries of research data collected as part of a class project by graduate students in the George Washington University's Procurement and Contracting program have been drawn upon for this report. These data are presented in table 1.

HISTORICAL NOTES

Type of contract has not often been an issue of public importance. An exception occurred during the late 1960's. At that time, toward the end of the tenure of Robert S. McNamara as Secretary of Defense, several major projects were exhibiting acute financial distress. Mr. McNamara had objected to the use of cost type contracts which had become fashionable with the procurement of technologically advanced weaponry during and after the second world war. Such procurements often included, in addition to production, the design and development of the system required. Mr. McNamara's policy was expressed by Business Week as follows:

> "Originally, McNamara balked at the cost-plus-fixed-fee award so common in the 1950's. He considered this the least efficient type of procurement because it not only reimburses contractors for all allowable costs, but guarantees them a profit whether their performance is good or bad. Therefore, he restricted such contracting largely to exploratory projects where technical uncertainties abound, and where no meaningful measure of performance can be established in advance.
>
> McNamara preferred firm fixed-price contracts because they force the government to prepare precise work statement at the outset, and motivate contractors to minimize cost overruns and schedule slippages to protect a profit that only good performance can bring." (2)

While it is questionable whether any type of contract "forces" particular behaviors on the parties, the general policy was clearly stated by the above quote. It was also stated by the secretary himself in the following:

> "Since 1961, we have made many significant improvements in managing Defense acquisition programs and in procurement policies. The cost-plus-fixed-fee environment of earlier years has been replaced by tighter management--both on our part and that of our contractors--as exemplified by the introduction of more intensive competition, more extensive use of incentive and fixed-price contracts, and greater contractor investment in plant and equipment." (3)

Regardless of these statements, problems of great magnitude involving cost, schedule and technical issues had arisen on several major acquisition projects which had been on a fixed price or fixed-price-incentive basis.

The problems encountered by C5A, Cheyenne Helicopter and other large acquisition projects of the 1960's gave rise to numerous studies including that of the Commission on Government Procurement commissioned by Congress in November 1969. (4) A clear reversal of the McNamara policy occurred on May 29, 1970 when Deputy Secretary of Defense, David Packard issued a memo that stated in part: "In all our contracting, the type of contract must be tailored to the risks involved." Mr. Packard intended the type of contract to be appropriate for the job.

Subsequently, the Armed Services Procurement Regulation (now Defense Acquisition Regulation) was revised to amplify treatment of contract type selection. (5)

CONTRACT TYPE UTILIZATION

The reader should note that table 1, Contract Type Utilization, is a tabulation of data collected by nine researchers (students) independently. Each of the researchers had a common set of research instructions but was asked to select either a government agency or contractor organization, to define a population of contract activity within that organization, and to select a sample representative of that population. One product of this effort is the distribution of contract types used by the nine activities sampled as presented in table 1.

One of the principle determinants of contract type is the mission and policy environment of the sponsoring agency. This fact is indicated by the data presented in table 1. For example, the DOE sample included three types of instruments not used by any other group. This factor results from the commercialization and demonstration objectives of DOE and the fact that public policy requires cost sharing of much of the agency's work. Because of these factors, grants and cooperative agreements are used extensively by DOE.

Table 1 also illustrates the predominance of cost type contracting in the samples tabulated. In all samples except one, cost type contract awards exceeded 50 percent of the total and in the aggregate, 71 percent of the contracts sampled were cost type.

TABLE 1

CONTRACT TYPE UTILIZATION*

Percentage Distribution For Nine Independent Samples**
Percent Based on Number of Contracts in Sample

TYPE	DOE (C&A)	CONTRACTOR	HUD (OPDR)	AID (R in A)	GSFC	EPA (OPM)	NAVSEA (R&D)	NAVAIR	NAVSEA (C&S)
CS	4				3				
CSg	20								
CSca	4								
CNF	8		64	19	18		1		2
CNFg	36								
CPFF	16	70	12	43	30	80	78	21	40
CPFFloe		8							
CPAF					9		6	4	1
CPIF			4				10	14	7
CPIFmi									1
FPR			12						
FPI								9	25
FPImi									11
FFPloe		2							
FFPepa								1	
FFP	8	19	8		36	17	6	51	11
LH				38					
T&M					3	3			
SAMPLE SIZE	25	46	25	126	33	41	799	81	115

* Populations sampled were uniquely defined. Samples taken during February and March, 1980.

** Contract types are: CS-Cost Share, CSg-Cost Share grant, CSca-cost share cooperative agreement, CNF-Cost No Fee, CNFg-Cost No Fee grant, CPFF-Cost plus Fixed Fee, CPFFloe-Cost plus Fixed Fee level of effort, CPAF-Cost Plus Award Fee, CPIF-Cost Plus Incentive Fee, FPR-Fixed Price Redeterminable, FPI-Fixed Price Incentive, FPImi-Fixed Price Incentive multiple incentive, FFPloe-Firm Fixed Price level of Effort, FFPepa-Firm Fixed Price economic price adjustment, FFP-Firm Fixed Price, LH-Labor Hour, T&M-Time and Material

SUCCESSFUL CONTRACTING: A PROPOSED DEFINITION

The contract is no more than a tool for management's use in carrying out its work. In the case of large, complex acquisitions, it becomes a substantial document that records an intended business relationship, one that must strike a balance with respect to the interests of the parties. It should reflect the nature of the undertaking and the interrelationships of the parties essential to success. In designing the contract, concern with outcomes is paramount. But outcomes (performance, schedule, cost) can only be hypothesized at the time of agreement. Therefore, the parties must anticipate the nature of performance, the type of problems to be encountered, the activities and communications necessary to problem reduction and the overall likelihood of achievement. The art of contract design lies in finding the terms and conditions that best facilitate achievement of success. Unfortunately, measurement of success in contracting is as much an art as is the formation of the agreement. But we need to define it so that we can shoot for it.

Clearly, no contractual success is possible if the technological or production objectives of the sponsor are not met or substantially met. Furthermore, technological and production objectives are intertwined with schedule, and success also demands that the sponsor's schedule for performance be met. Since these objectives are subject to change, the contract instrument should also facilitate the change process. Finally, cost objectives are critically important to the party holding responsiblility for costs. This, depending on contract type, could be either party or it could be shared. In essence, success must be defined not only in terms of technological production and schedule achievement, but also in terms of the ability to update and to discharge

business obligations. Thus contractual success is a coincidence of three moving images: technical and production requirement fulfillment, contract schedule compliance and financial expectation adherence. In short, success is the relationship between expectations and outcomes.

THE PROCESS OF SELECTING CONTRACT TYPE

According to Government Procurement Regulations (such as the DAR) contract type determination is the responsibility of the contracting officer. (6) But the contracting officer is not chartered to perform the task alone, particularly in the case of R&D procurement. Instead he is required to obtain a recommendation from cognizant technical personnel. (7) The regulations also hold that contract type is a matter for negotiation, (8) but in numerous interviews conducted for this report, it is clear that most agencies decide upon the contract type prior to issuance of an RFP. Furthermore, contract type intentions are set forth in the "acquisition strategy" document now required in connection with planning for major systems acquisitions. Under those conditions, it would appear that the decision on contract type is normally made prior to formal involvement of the potential contractor.

In practice, contract type is approached in several ways. It may be decided by top management. It could be decided in negotiations. The contracting officer or negotiator may decide it in preparation of planning or negotiation documents. On occasion, an intended contract type is modified as a consequence of events such as refusal of potential sources to respond to an RFP. Two instances of this were cited by interviewees. Frequently, the best contract type is, reportedly, evident to all participants and little or no discussion occurs. A limited number of actions is pre-determined by statute as in the case of energy related demonstrations financed by DOE in which a grant is prescribed by statute and the DOE Assistance Regulations prescribe payment of fee under the grant. (9) Also recent use of draft RFP's circulated to potential contractors for comment has in some cases provided information that influences the decision.

With respect to its impact on operations, the persons/groups principally affected by contract type are the government project or technical team, the contracting officer or negotiator, and their counterparts working for the contractor. Each of them must live with and administer the project under the conditions set up by the contract. Nevertheless, several interviewees held that the decision is rarely made through their interaction at the negotiation table, rather it is a policy matter and is decided in earlier stages of planning. Contractor interviewees found that their best opportunity to influence the contract type occurs in discussion with project and policy level personnel of the government in advance of RFP issuance. This was confirmed indirectly by government interviewees who indicate they keep channels of communications open so that contractor ideas will be available and expressed--and that "there are no shrinking violets out there."

The power of individuals and offices to influence contract type depends in part on expertise and in part on the responsibilities vested in the office held. Technical uncertainty must be assessed by technically knowledgeable persons. Assumption of risks, however, must be decided by persons qualified and appointed to carry responsibility for the overall business risk. This applies to sponsor and performer organizations equally.

Additional techniques cited by contractors for influencing contract type included submission of alternate proposals, negotiation for insertion of risk allocation clauses, and where pertinent, submission of unsolicited proposals in which type of contract is specified.

In some cases, contractor policy positions are as specific as government positions, although they may not be published. One respondent would object strongly to any fixed price development contract. Another would object to fixed priced software development. In both cases, the concern expressed was with the degree of unknowns. The respondents declared they would resist any case of "bet your corporation."

Based on the interview data, it appears that contract type is not a major issue in most acquisitions yet it remains crucial to the interests of the parties. The area of greatest sensitivity is fixed priced contracting when development work is required. Interviewees in government positions expressed concern with risk allocation as did contractor representatives. There appears to be a consensus that high technology projects of the government are best managed if the principal risks rest with the government.

CRITERIA FOR CONTRACT TYPE SELECTION

Several authors have attempted to set forth criteria for selection of contract type. (10) Their efforts are helpful, but the dynamics of contracting warrants our taking a new look at the problem from time to time. With the expanded treatment of contract types now found in the procurement regulations, the practitioner has no shortage of official guidance. Still, in our surveys of key personnel in the contracting community, the question of criteria elicited a spectrum of responses like "It's obvious 80 percent of the time," and "It's a crucial issue to me on every major acquisition." That kind of diversity of view is in part accounted for by individual experiences and in part by the level at which the matter is considered. If one is thinking only of "contract type" in the sense of cost type versus fixed price, the alternatives are few. However, contract type, inclusive of formula and award concepts, multiple independent variables, ceiling levels, incentive slopes, and risk modifying clauses presents the negotiator with an unlimited set of choices. It is in that context that the following criteria are developed.

There are many choices and every undertaking has some unique combination of objectives and circumstances to which the contractual agreement should be fitted. The criteria proposed here are thought to cover most situations--all have been suggested by leading practitioners interviewed for this study as criteria of importance--but they are not presented an an exhaustive list. There are surely many others that, in given situations, may govern the negotiation.

Current State of the Art. This, together with the second and third items, is the basis for determining the nature and scope of technological uncertainties associated with performance. These uncertainties are critical to proper selection of contract type. They are viewed as the principal source of risk with respect to achievement of program objectives. The current state of the art if in equilibrium with respect to the requirement, minimizes risk to be allocated between the parties. However, when elements of required performance mandate an advance from the current state of the art, the level of uncertainty increases and the parties must carefully consider who assumes the risk that the advance might not be achievable.

Current Stability of the Technology. This criteria viewed in concert with criteria one, refers to rapidly evolving knowledge found from time to time in specific fields. It is a source of uncertainty with respect to acceptability of program achievements. In a changing state of knowledge, contractual specifications may fail to adequately express what performance is acceptable. This situation gives rise to the problem of a moving base line and to an associated uncertainty respecting contract completion. As a consequence, it is a source of risk for allocation between the parties.

Nature of the Contract Specification. Again, this element might be viewed in concert with criteria one. The technical documentation is expected to delineate what party is responsible for particular effort and to establish criteria for acceptance of the performer's work. Uncertainty is increased when the contract documentation lacks clarity in either of these aspects. A low level of clarity could result from poorly drafted documentation or from the nature of the effort. For example, reliability and maintainability standards might involve sensitive judgements as to the level of achievement even though the acceptance standard may appear to be exact. If the nature of the work lends itself to exacting specification writing, and if the specification is clearly written as to who performs specific effort and as to acceptance criteria, uncertainty is minimized. Otherwise the contractual risk allocation should carefully consider these uncertainties.

Program Objectives. The emphases, or prioritization, of broad program objectives such as schedule, cost and performance implies much with respect to contract type. If limitation on program growth (in cost terms) is critical, the type of contract would tend toward the more advanced forms (the fixed price types). A similar implication arises from tight schedule objectives. These objectives, however, imply limitation of emphasis on technological achievement and therefore imply either limitation on performance requirements or movement toward risk adjusting contract provisions such as term type or level of effort clauses. The basic trade off is between cost emphasis and technological emphasis. Advanced contract types are consistent with cost emphasis and vice versa.

Program Importance. While all programs are important to the involved parties, the level of interest and importance accorded to the effort by top management or political decisionmakers influences the viability of contract types. A necessity for increased visibility implies greater levels of detail in technological and financial reporting, greater facility in adjusting project plans, and in general, lower stability for execution of effort. High levels of program importance therefore would indicate movement toward the less advanced (cost type) contract types. The reimbursability of costs tends to facilitate the sponsor's expressing needs for information and other behaviors responsive to special demands.

The need for maintenance of visibility over the life of major programs is also a factor in use of award fee contracts. The periodic "report card" in support of award decisions stimulates intense interest in program progress by top management of both parties. It continues as a stimulative force over the life of the program, long after the glow of newness is gone.

Program Stage. This factor is illustrated by para phrase of an interview: Conceptual studies generally go out fixed price. We use them in following A-109. Funding of these studies is limited by budget, and contractors regularly overspend the allotted funds and have to absorb the costs. This is the business decision, but they do it so as to be ready for validation phase contracts. There isn't much risk involved since the product of their efforts is their conceptual design and approach to meeting the mission need of the agency. The validation work will move to the CPAF contract, with perhaps an IF feature to encourage cost reduction. Full scale development will involve a cost type contract. We don't want anything that vaguely resembles the TPP era. Usually we go with award fee although for performances that are clearly defined and measurable, we will use multiple incentives. As we move to production, FPI is our objective, but it may be delayed beyond pilot and first or second production contracts because design stability won't be reached that early. The multiple incentive versus award fee issue is largely a question of measurability of performance as opposed to its judgemental quality.

Duration. Several sources of risk were associated with duration by interviewees. Specific risks were: a) possible termination for convenience; b) inflation; particularly the amount of inflation pertinent to performance cost; c) risk of funding cut off in multi-year production; and d) extent

of warranties, particularly the number of production units over which design warranties might be extended. Each of these risks, if considered dangerous to the contractor, were bases for movement toward less advanced contract types, or in the case of inflation, adoption of economic price adjustment clauses. Also movement to FPI was considered as a way to share the risk of escalation if there were extensions of the performance period.

Motivational Factors. Each contract type conveys messages respecting what the sponsor wants the performer to emphasize, However, the motivational force of contractual provisions may be limited by several circustances. One of these is the disconnect between contractual incentives and the performer's decisionmakers. The contractual incentives for decisions desirable to the sponsor may not be perceivable at the level of the corporate manager making the decision. The translation of contractual provisions to workers is dependent upon the management policies of the performer. Another limitation is that the motivational force (the bait) in contracts (with two exceptions) is limited to profit dollars payable under the instant contract. As a consequence, other motivational forces may overwhelm the impact of contractual profitability outcomes. Examples of powerful non-contractual pressure are reputation of the performer, maintenance of performer work force, amortization of performer facility investments (particularly in periods of overall decline in sales by the contractor), potential for winning new business and overall corporate strategies respecting the future business mix.

The two contract types that may provide contractual motivational forces beyond the instant contract profit are award fee contracts and contracts which provide for value engineering incentives payable for program cost reductions. The award fee contract is an exception only because of its periodic "report card" feature. Although the amount of award fee available is limited to to the instant contract award fee pool, the impact of a good report card versus a bad report card may be an extremely powerful motivational tool when used effectively. The value engineering incentive differs in that it is strictly a monetary motivator, but is still exceptional because it may offer the potential of a profit return on future production savings which can far exceed instant contract profit potential.

Past Performance of Contractor. While past performance is better recognized as a factor in source selection than in contract type selection, it influences the contract type in some circumstances. One agency which uses CPFF and CPAF contracts for services extensively, prefers CPFF whenever a contract is going to a contractor who has demonstrated excellent performance. This approach is applicable where the extra motivation of the report card is unnecessary. Conversely for similar services with an unproven source or one believed less effective in terms of the agency's standards, CPAF is used.

Legal Constraints. Contract type was not perceived as greatly affected by legal constraints. Statutory and regulatory limitations on fee on cost type contracts did not appear to be a problem. However, the statutory limitation on the amount of cancellation charges payable for multi-year contracts was believed to constrain the use of multi-year provisions for production in a few cases. Where this issue was a factor, three possibilities arose. One was to move toward a cost reimbursable contract (so that cancellation risks would not be borne by the contractor) and then attempt to manage the production process and subsequent awards so that the cost savings based on production continuity would be preserved. This approach suffers from the problem that if the production could otherwise employ a fixed price contract, a cost contract is difficult to justify. Also it forces the current budget to absorb the entire start up cost. Another approach, cited for one recent situation, was to proceed with the multi-year contract award even though cancellation costs far exceeded the limitation. This was based upon the contractor's high confidence that subsequent year funding would be provided due to the nature and urgency of the product. This approach, however, places the risk of future program funding on the contractor. The third alternative was to revert to one year production on a fixed price basis with no explicit effort to reduce price through avoidence of re-incurrence of start-up costs.

Production Potential. In one case cited by an interviewee, a research and development contract was awarded on a firm fixed price basis under conditions in which development cost estimates were believed to be sound but still uncertain. In that case, contractor willingness to use the firm fixed price arrangement was based upon high confidence that follow-on production was assured and that little or no likelihood existed of other sources capturing the entire production.

Contract Management Complexity. Complexity in contract management appears to be related to technological complexity, duration, and magnitude of the program. It is affected by the number of contractors involved, the number of agencies involved, relationship of the immediate work to existing capabilities and plans, and management philosophy of key leaders. This factor can be crucial to contract type decisions. High complexity suggests less advanced contract forms.

Complexity discussions also brought out two facets of the management problem. One was the question of contractor responsiveness to program demands. The other was discipline with respect to the buyer's program offices. The advanced contract types are believed to reduce responsiveness but may increase discipline. Fixed prices, tight ceilings, and steep incentive slopes, make it critical that the performer manage effectively, and similarly, critical that the sponsor uses keen discretion in oversight activity. Conversely, CPFF reduces criticality in administration. Interestingly, because of its "report card" procedure,

the CPAF contract was believed by several interviewees to enhance both discipline and responsiveness.

Independence of Action During Performance. Independence of action is indicated by the level of interaction between sponsor and performer personnel while work is in progress. The level believed to be necessary at the time of contract formation is keynoted by the sponsor's technical management. The level of interaction needed should be assessed, and contract type should reflect that relationship. In general, low interaction allows advanced contract types; high interaction is supported by the less advanced contract types.

Administrative Costs. The cost of administering contracts plays a part in contract type decisions. The least administrative cost situation is associated with the most advanced contracts (Firm Fixed Price). Under these audit is not required, and the oversight activities of sponsor can be minimized. The performer expects to provide minimal information services beyond specified deliveries. Conversely, all cost or incentive contracts require cost reviews and assessment of status with respect to the incentive. The award fee is believed to maximize administrative effort. Fixed rate contracts (time and material, labor hour) require regular administrative attention to assure proper application of effort. As a consequence, sponsoring agencies must assess their ability to carry on oversight work when they select the less advanced contract types.

Use of Government Furnished Property. Property furnished by the sponsor alters the appropriateness of advanced contract types, particularly when in combination with development effort. Use of GFP opens the relationship to complex assessment of suitability of the property to the work effort. Similarly its availability and timeliness for use by the performer may become an issue. Additionally, property such as data may be difficult to assess with respect to deficiencies. As a consequence, when an acquisition requires provision of property by the sponsor, the contract type may need to be adjusted to provide an appropriate level of interaction between the parties respecting the use of the property.

Availability of Cost and Pricing Data. All of the contract types except firm fixed price entitle the contracting agency's audit organization to review the actual costs of performance. Additionally, comprehensive technical, cost, and management reporting systems are activated primarily for non-firm-fixed-price contracts. As a consequence, when an agency is concerned with obtaining detailed information concerning performance, the contract type applied would be likely to fall in the incentive or cost reimbursable categories.

Accounting Systems. Principally in the case of small business, adequacy of the contractor's accounting system may be a factor in preferring FFP contracts. This was not viewed as an issue in very many situations.

CONCLUSIONS

First, the processes and criteria bearing on contract type selection become evident only when the participants are fully aware of background factors, plans, uncertainties and communications expected during performance. The decision calls for an acute sense of the needs of the acquisition. It is a judgement which, hopefully, can be made more effectively as a result of research such as that reported here.

Secondly, the appropriateness of fit of a contract to the acquisition, while believed crucial to the management of the relationship, could not, by this research be shown clearly to be related to the degree of success in the outcome.

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LOGISTICS/ILS

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AIR FORCE APPLICATION OF LOGISTICS SUPPORT ANALYSIS

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ABSTRACT

Analysis, an inherent part of the systems engineering process, starts with the definition and establishment of a system or equipment's operational requirements. These analyses are conducted within the engineering disciplines and form the framework for the design and logistics trade-offs that lead to the definition of the total system. Logistics Support Analysis (LSA) is that segment of the systems engineering process that seeks to bind these individual analyses into a single, comprehensive analytical program. LSA program requirements are contained in MIL-STD-1388. The standard was published in 1973 as an Army, Navy, and Air Force coordinated document; however, it was not until Oct 1978 that a decision was made to implement MIL-STD-1388 formally within the Air Force. This paper will (1) outline the events leading to the Air Force acceptance of LSA, (2) describe the LSA process, (3) identify the management actions taken/to be taken to institutionalize LSA within systems engineering, and (4) discuss the interactions between the services to promote uniformity of application for LSA.

BACKGROUND

MIL-STD-1388 was published in October of 1973 as a Joint Military Service document. The goal was a single, uniform, Tri-Service process for conducting a logistics support analysis program. However, the publication of the standard did not signal the start of a concerted effort, within the Air Force, to apply MIL-STD-1388. The MIL-STD was, for all practical purposes, relegated to the shelf. There was a reason for this. Both AFLC and AFSC believed the processes and procedures outlined in the MIL-STD could not be effectively incorporated into the Air Force acquisition activities. In 1976, both commands formally expressed dissatisfaction with the MIL-STD. Their dissatisfaction was based on the belief that the standard:

A. Is too general and difficult to convert into useful activity.

B. Is not structured to suit Air Force practice of obtaining logistics support analysis.

C. Leads to generation of data which is duplicative and/or unneeded.

The dissatisfaction led to a proposal from the Air Staff that a small working group be established to prepare an Air Force MIL-STD for logistics support analysis. The new MIL-STD would have been subordinate to and would complement MIL-STD-499A (Engineering Management). The Air Staff proposed Headquarters AFLC take the lead in the project.

In the fall of 1977, Headquarters AFLC proposed the Air Force Acquisition Logistics Division (AFALD) assume responsibility for the project with AFLC and AFSC acting as a steering committee. AFALD accepted the assignment and formed a work group to accomplish the task. A plan for accomplishing the assignment was prepared and submitted to the steering committee for approval. The plan was approved in January of 1978.

The plan required a review of selected programs applying MIL-STD-1388. The reviews were to determine how LSA was being planned and implemented and its role in the systems engineering process. Based on the information obtained, specific recommendations were to be submitted to the AFLC/AFSC steering committee.

In early 1978 there weren't many Air Force acquisition programs using MIL-STD-1388. Most of the activity was located at the Electronic Systems Division (ESD) in Massachusetts. These programs were Joint Service efforts and MIL-STD-1388 was used at the insistence of the Army. The Simulator Program Office, located at Wright-Patterson Air Force Base, Dayton, Ohio, was using the MIL-STD; however, this effort was somewhat abbreviated. The reviews conducted by the LSA work group centered around the ESD programs and the Simulator Program at Wright-Patterson AFB.

It is not the intent of this article to provide the detailed findings of the work group; however, the conclusions upon which the report and recommendations were based are important. These conclusions were:

A. MIL-STD-1388 was conceived to satisfy a need for communication within the systems engineering program. Properly applied, the LSA process outlined in the MIL-STD serves that need. There are other benefits of LSA. LSA provides a systematic

approach for documenting and controlling engineering and logistics data. LSA also provides visibility. This visibility provides managers the opportunity to evaluate progress toward satisfying ILS objectives.

B. The key to maximizing the benefits of LSA is early planning. The Air Force had yet to perfect early LSA planning. As a result, our contractual instructions have not been sufficiently expansive and forceful to ensure proper integration of LSA into systems engineering processes. Improper integration of LSA tasks into the engineering process can create an environment whereby the AFLC/AFSC concerns expressed in 1976 could be realized.

LOGISTICS SUPPORT ANALYSIS OVERVIEW

Analysis, an inherent part of the systems engineering process, starts in the conceptual phase and continues through into the production phase. These analyses are conducted within the engineering disciplines and form the framework for the design and logistics decisions. LSA, as described in MIL-STD-1388, is that segment of the systems engineering process that seeks to bind these individual analyses into a single systematic, comprehensive analytical program. The LSA tasks (e.g., maintenance planning, logistics requirements identification) will intermesh with the engineering efforts and disciplines, such as reliability, maintainability, human factors, standardization, and transportability to influence system design. The number and types of analyses and trade-offs vary according to program schedule and depth of engineering required to meet specification requirements. As the design evolves, records shall be maintained to provide the basis for development of logistics constraints, identification of design deficiencies, and identification and development of essential logistics support resources. Logistics risks and deficiencies will be identified and methods for overcoming or minimizing these problems will be developed.

A prerequisite to the effective development and conduct of the individual analytical processes formed together under LSA is the establishment of lines of communications between the various systems engineering disciplines performing the analysis and associated trade-offs. The free flow of design and logistics data via these communication channels is important to the integration process and accomplishment of program objectives. This was recognized early in the development of the LSA MIL-STD, and a program was initiated in 1974 to design a mechanized data system to complement the communication process. Initial design work was completed in 1975 and contractually applied by the Army in the same year. The mechanized data system is designed to complement the LSA process, and can be tailored to accommodate the individual characteristics of each acquisition program.

IMPLEMENTATION PROGRAM

In August of 1978 the AFALD submitted to the AFLC/AFSC steering group a report of the results of the work group's study effort with specific recommendations (with tasks) for implementing an Air Force LSA program. The report and all recommendations were approved. The approval did not necessarily reflect a complete change in the beliefs and concerns expressed in 1976. However, the report, and more importantly the recommendations, identified a means of correcting the conditions that produced the concerns.

The recommendations were based on the importance of the Air Force's role in developing, implementing, and managing an effective Logistics Support Analysis program. All recommendations addressed the actions the Air Force must initiate to make MIL-STD-1388 an effective acquisition management tool. Essentially, what the recommendations pointed out was the need to integrate our contractual requirements. The Air Force can no longer develop and manage the various engineering (both design and logistics) disciplines independently. With this in mind, the following recommendations are being used as the implementation plan.

IMPLEMENTATION REQUIREMENTS

Although LSA is considered primarily a contractor oriented process, it must be recognized that the form and function of LSA (within the contractor environment) is determined by the Air Force. To make LSA an effective tool, it is necessary for the Air Force to adjust/mold its management activities to support the goals and objectives of LSA. Past efforts to integrate systems engineering disciplines were oriented to specific programs. The BSD Exhibit 68-62, AFSCM 375-5, and Maintenance Engineering Analysis Report (MEAR) are examples of individual efforts that preceded MIL-STD-1388. These were essentially Air Force Systems Command oriented programs. However, the supporting and participating commands (AFLC, ATC, Using Commands, etc.) play a vital role in the acquisition process, not only in terms of management, but in developing the basic system requirements. Therefore, it is important that the application and integration of LSA into the acquisition management process be a total Air Force effort. The recommendations submitted to, and approved by, AFLC and AFSC were directed toward that end.

The first recommendation was to establish Air Force policy on LSA. The LSA process cuts across many functional areas and directly impacts the management processes of the implementing, supporting, and participating commands. To provide for the proper recognition and implementation of LSA, the Air Force would need to establish overall policy and responsibility for its application. Air Force Regulation 800-8 (Integrated Logistics Support (ILS) Program), published in February of

this year, requires the use of LSA by government and contractor logistics and design engineers. Requests for waivers of LSA application must be submitted to HQ USAF for approval. The publication of the Air Force regulation signifies a solid commitment to the LSA program.

Currently, AFLC/AFSC policy and guidance pertaining to LSA is contained in a joint service regulation titled "Standard Integrated Support Management System (SISMS)." SISMS must be used in multi-service aeronautical systems/projects where an Executive Service has been assigned. Mandatory use of SISMS on other systems/projects is not required. With a mandate to apply LSA to totally integrate LSA into the Air Force's acquisition activities, it would be very difficult to develop and implement the program successfully through a regulation whose use is optional. To establish LSA as a systems engineering process jointly agreed to and implemented by AFLC and AFSC, it was recommended a separate regulation be published. The regulation would provide detailed information on the interrelationships and responsibilities of the commands in implementing and managing LSA. A draft regulation has been prepared and is currently being reviewed by staff personnel.

The third recommendation was to define the total role of LSA within systems engineering documents. Engineering documents available to assist government and contractor personnel in defining systems engineering provide little information on the role of LSA. For example, MIL-STD-499A (Engineering Management) presents criteria for contractors to propose their internal procedures for satisfying engineering requirements. However, LSA is portrayed as a nonmandatory task. The MIL-STD also fails to identify the total scope of LSA. It confines LSA to three functions: the conduct of maintenance engineering analysis, the repair level analysis program, and logistics support cost modeling. The requirement to identify qualitative and quantitative logistics support requirements and the role of LSA in assessing the achievement of logistics objectives are not included. There are other engineering documents (e.g., reliability and maintainability) that will require updating to provide for total integration of LSA into systems engineering. However, MIL-STD-499A is considered important because it provides the baseline for engineering planning.

One of the most important LSA tasks is to review historical data in order to relate past experience to the design requirements of new acquisitions. Such information as failure rates, major downtime contributors, and repair times on like or similar items provides a basis for establishing qualitative and quantitative requirements on new equipment. Discussions with contractor personnel indicated information of this nature is difficult to obtain and, when available, is not always in a usable form. Therefore, it was recommended that an interface be established between the LSA data system and AFLC's internal data management systems (e.g., the Master Material Support Record (D049)). This will require changes to the data structures by the Logistics Command. An additional benefit of this interface is the availability of LSA data to depot managers. Access to this information would facilitate early depot planning.

One of the functions of LSA is to assess the achievement of logistics objectives. Without a good LSA program, the Air Force does not have a consistent method for accomplishing this assessment. Discussions with the Air Force Test and Evaluation Center (AFTEC) confirmed a need for a consistent approach to providing engineering and logistics development data to test and evaluation programs. Previously, these data have been extracted from various engineering and logistics reports or provided through special arrangements with program offices. It was recommended the Air Force provide within LSA implementing procedures the mechanics for identifying and satisfying AFTEC data requirements. As a companion to this recommendation, it will be necessary to develop procedures for feeding the test results back to the LSA process for use by the Air Force and contractors in adjusting support planning.

The report contained one recommendation that can be construed as being directed toward the contractor. This was to establish the LSA data system as the single source of design related logistics data pertaining to acquisition programs. This is an important step for both the contractor and the Air Force. For a contractor, it could mean redesigning an internal data system or using a data system provided by the government. For the Air Force, it will mean screening and validating our data requirements to insure conformance with the LSA data system. The establishment of the single integrated data base will inhibit the development and use of duplicate or inconsistent data.

The analysis and associate trade studies conducted during systems engineering are many and varied. They are accomplished to meet specification requirements and are critical to the design of the equipment and its support system. For major system acquisitions, there can be in excess of 2000 identifiable trade studies conducted as part of the design process. Logistics will be an important factor in these trade studies <u>if</u> qualitative and quantitative support requirements are included in the specification. The report made no effort to identify these trade studies. However, there are specific trade studies required that were addressed in the report and resulted in a recommendation. These trade studies were the Life Cycle Cost and Repair Level Analysis efforts. Both are recognized as being major factors in acquisition management. Important elements in projecting LCC are the operating and support (O&S) costs. Within the LSA process is the ability to develop and document the engineering and logistics information required to estimate O&S costs. The LSA process also provides the mechanism for

informing engineering of the LCC implications of a design in sufficient time to permit design changes. However, there needs to be a correlation between the LSA data base and the data required to drive the LCC model. We cannot afford to use one set of logistics data to develop the support system and a different set to operate the LCC model. The same situation exists with the RLA program, only with an added twist - very detailed RLA models have been developed. Not all the logistics engineering data required to operate the economic models are available in the LSA data system. This will have to be corrected. Another important factor is the intricacies of the models. At the point in time repair level analysis can be used as an effective design tool, the data to drive the model isn't always available. Therefore, there is a need to simplify these models. There is much to do before the LSA, RLA, and LCC programs are successfully integrated.

One of the recommendations was to revise MIL-STD-1388. The document has not been changed since its publication in 1973. Both the Army and the Navy have developed supporting publications, but the MIL-STD has remained essentially the same and requires updating to meet today's systems engineering requirements. The data element dictionary needs to be changed to conform to current engineering specifications and military standards. Provisioning and reliability data elements are two examples where inconsistencies exist. The tailoring of the LSA process must be more clearly explained, and task statements should be made more explicit. Because MIL-STD-1388 is a Joint Service document, changes must be coordinated and approved by the Army, Navy, and Marine Corps.

Government documents describe the provisioning process as commencing with a production contract. In reality, many provisioning decisions are made during the design/development phase as part of the LSA effort. They are products of the designers' efforts to satisfy reliability and maintainability requirements. These design constraints and the manner in which the designer reacts to these constraints are critical to the spare and repair parts program. The repair level analysis process, another design activity, determines where spares and repair parts will be positioned. These actions, along with other design activities, determine the critical provisioning issues. After the production contract, the role of provisioning becomes that of establishing support records (cataloging-requirements records) and taking procurement actions. It is therefore necessary to establish provisioning requirements at the beginning of the full-scale engineering development phase. Provisioning data will be entered in the LSA data system as it becomes available and all Air Force provisioning data requirements will be satisfied from the one LSA data base. The recommendation concerning the need to integrate provisioning into the LSA processs appeared on the surface to be reasonably easy to accomplish. However, before the integration can be completed the Air Force's mechanized provisioning system (D-220) will require a partial redesign. The reason is the LSA data system uses a Work Unit Code - Work Breakdown Structure oriented control number while the Air Force's provisioning system uses the Provisioning List Item Sequence Number (PLISN) system.

The last recommendation that will be discussed in this paper deals with establishing an Air Force education program for LSA. A serious handicap in developing and implementing successful LSA programs has been the lack of understanding of LSA and its relationship to systems engineering. Air Force personnel assigned to, or assisting, program offices in the planning and management of an acquisition are faced with the dual tasks of comprehending the LSA concept and relating it to other acquisition activities while developing management plans and contractual documents. It is very important that the Air Force develop and implement an effective training program. On a short-term basis, this means conducting briefings and seminars for program office and air logistics center personnel. On the long-term basis, it was recommended that selected training courses at the Air Force Institute of Technology be expanded to include material on LSA.

INTERSERVICE ACTIVITY

In October of 1978, the Air Force hosted a Joint Service meeting to share experiences and exchange information on the problems (and solutions to problems) in the application of MIL-STD-1388. The Army and Navy were experienced in the application of the MIL-STD and it was believed they could help in the Air Force's implementation effort. Considerable information was exchanged; however, the most significant product of the meeting was the establishment of a Joint Service LSA Work Group. The purpose of the work group is to provide a forum for discussing, determining. and writing techniques and procedures for implementing LSA. In 1979, the membership of the work group was expanded to include representatives from industry. Members from the National Security Industrial Association, the Electronic Industries Association, and the Aerospace Industries Association serve as advisors and are taking an active and important role in the work group's activities.

The initial effort of the work group is to update the data element dictionary, revise the LSA input sheets, and identify output summary requirements. An adjunct to this effort was a study to determine the required interfaces between the LSA program and the human factors engineering program. The study resulted in changes to the LSA data base to provide human factors information. The work group will also determine the feasibility of expanding the LSA data system to include embedded computer information.

The Joint Service LSA Working Group's efforts to establish a uniform data element dictionary exposed a need to control and manage the LSA data and data system. To effect this management, a number of options are being analyzed. The basic

idea is to form a central DOD standard LSA data system design activity. The design activity would be under the direction of a four-member Joint Service LSA Board. A decision on the validity of this approach will be made at the next work group meeting.

The total structure of MIL-STD-1388 will be revised. Plans are to structure the document in the following manner:

MIL-STD-1388	Basic Instructions and Task Statements
Appendix A	Data Element Dictionary
Appendix B	Data Sheets and Tape Formats
Appendix C	Output Summaries
Appendix D	Data Item Descriptions

In support of the revised MIL-STD the following Military Handbooks will be prepared:

Functional User's Guide
ADP Program (GFP Software)
ADP Program Guide
LSA Management Guides
- Contract Tailoring
- LSAR Tailoring
- Review Team Responsibilities

The development of the LSA program and establishment of the management processes for integrating it into systems engineering is an ambitious task. The changes in our acquisition planning and management, required by both the government and industry, will not come easily. It is much more difficult to develop and implement LSA in a Joint Service environment. However, interservice cooperation will mutually benefit all. For you in industry, the benefits will be in terms of uniform application of LSA; that will ease the need to individualize your program management structures. For the government, the efforts of the work group will enhance our ability to communicate internally in an effective manner.

SUMMARY

The successful integration of LSA into our acquisition activities rests with both the government and industry. The first and most important step in the integration process must be taken by the government. Our acquisition management procedures must be aligned to complement the LSA process, and we must identify to industry clear definitions of the Air Force's LSA requirements and objectives. This will provide industry a firm basis for accomplishing their responsibilities to the LSA program.

AN INVESTIGATION OF THE SOFTWARE REQUIREMENTS ALLOCATION PROCESS IN THE ACQUISITION AND MANAGEMENT OF A MAJOR DEFENSE SYSTEM

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ABSTRACT

This paper summarizes a comprehensive investigation of the software requirements allocation process. The Department of Defense and Air Force policies and procedures on requirements allocation were summarized, the allocation decision criteria were identified and evaluated, and the feasibility and potential impacts of an alternate methodology, called "Horizontal Allocation," were evaluated. A comprehensive literature review and semi-structured interview of government and industry "software experts" were used to collect the research data. Both qualitative and quantitative analysis techniques were used to interpret the data. Several significant problems assessing development status, achieving system integration, and delivering a system within approved cost and schedule constraints were attributed to the present allocation process. On the other hand, the experts strongly endorsed "Horizontal Allocation" as a methodology that will favorably impact the cost, schedule, and management parameters normally associated with an acquisition program. Over 75% of the respondents indicated that this methodology should be implemented on future programs.

INTRODUCTION AND BACKGROUND

Modern weapon systems make extensive use of computers and software to perform functions which were previously performed manually, by hardware, or were not performed at all prior to the advent of computer technology. As a result, the importance of software in the Department of Defense continues to intensify as new systems emerge in response to increasing threats and declining force levels. Thus, computer technology has become a resource that is vital to the defense of our country.

This technology has placed a tremendous strain on the fiscal assets of the Department of Defense (DOD) and the Air Force (AF). In 1974, estimates of the annual Automatic Data Processing (ADP) costs in the DOD were $2.9 billion to $3.6 billion for software and a total of $6.2 to $8.3 billion when hardware and ADP resources were included. The software-hardware cost ratio was approximately 1:4 in 1955, while the 1985 ratio is projected to be 9:1 [1]. In fact, on one existing program, the World Wide Military Command and Control System (WWMCCS), the ratio is already in that vicinity [2]. Given such ratios, it becomes increasingly important not only only to cope with this technology but to master and exploit it, both from a technical point of view and, equally important, from a management and policy one.

The need to manage software as a critical component of a defense system over its life cycle is becoming widely recognized. A general awareness of this need as a defense-wide problem has been growing as software problems have reached top-level management visibility with increasing regularity. In July 1978, Barry C. DeRoze and Thomas H. Nyman of the Office of Secretary of Defense stated, "It is our opinion that DOD has been doing a poor job managing this increasingly important resource, and further, we have been doing little to encourage the application of science and technology to improve it. Both of these shortcomings must change!" [3].

In reflecting on a number of large, complex computer systems, Dr. Frederick Brooks relates the development of large software projects to the mortal struggle of prehistoric beasts trying to escape the tar pits:

> Large-system programming has over the past decade been such a tar pit, and many great and powerful beasts have thrashed violently in it. Most have emerged with running systems - few have met goals, schedules, and budgets. Large and small, massive and wiry, team after team has become entangled in the tar. No one

> thing seems to cause the difficulty - any particular paw can be pulled away. But the accumulation of simultaneous and interacting factors bring slower and slower motion. Everyone seems to have been surprised by the stickiness of the problem, and it is hard to discern the nature of it. But we must try to understand it if we are to solve it [4].

For many years, the DOD has had its own version of the tar pit problem. Difficulties have appeared in systems supporting all functional areas, including management support, command and control, intelligence, communications, logistics, and embedded computer systems. In fact, several recent defense-sponsored studies have shown that most software development projects are unsuccessful in terms of performance, schedule, and cost. The final software product delivered to the user often deviates significantly from the original specification; delivery schedules are sometimes slipped for years; and cost overruns are often on the order of 200 to 300 percent [5]. Thus, one of the most critical periods of the software life cycle which needs additional management emphasis is the acquisition process.

This process is initiated with the approval of a mission need and extends through five major phases with an affirmative decision required as preliminary to proceeding into the second, third, and fourth phases. The implementation of this process is accomplished by a complex set of interrelated, but separately identified, management disciplines. These disciplines are engineering, procurement, program control, test and evaluation, deployment, integrated logistics support, data management, and configuration management. Two of these, engineering and configuration management, are intimately related in the system acquisition process. Engineering, as used here, refers to any or all of the various areas of technical effort involved in acquiring a system. Within this broad concept, the engineering discipline is responsible for requirements analysis, design studies, evaluation of performance, cost and schedule impacts of engineering change proposals (ECPs), deviations, waivers, and technical direction to the developer. The products of these analyses, studies, and evaluations are the concern of configuration management.

Therefore, configuration management is a discipline that integrates the technical and administrative direction, and surveillance to:

1. identify and document the functional and physical characteristics of a configuration item,
2. control changes to those characteristics, and
3. record and report change processing and implementation status [6].

The first of these, configuration identification, is normally established in the form of three baselines during the development of a system. They are the functional configuration identification (FCI), allocated configuration identification (ACI), and product configuration identification (PCI) [6].

Since weapon systems are not procured as a single identifiable system but rather as separate end items of contractor developed, federal supply stock, and commercial "off-the-shelf" items, a number of configuration items are normally identified for each system. This process is initiated when the system requirements are validated and documented in the form of a system specification. The approved requirements are then allocated to individually-identified subsets, called configuration items (CIs) for hardware and computer program configuration items (CPCIs) for software. This process establishes the allocated configuration identification for the system, and is often called "CPCI selection". Thus, the number and composition of configuration items is a critical design issue since the Government's technical management activities primarily focus on CIs and CPCIs.

This paper documents a comprehensive investigation of the software requirements allocation process in the acquisition and management of a major defense system. The DOD and AF policies and procedures governing software requirements allocation were summarized, the allocation decision criteria were identified and evaluated, and the feasibility and potential impacts of an alternate methodology, called "Horizontal Allocation," were evaluated.

DEFINITION OF HORIZONTAL ALLOCATION

Horizontal Allocation is an approach to allocating system requirements to CPCIs on the basis of system versions or models, each of which contains end-use system functional capabilities. Therefore, a CPCI is equated to a version/model or series of versions/models for management purposes. In other words, a CPCI is a functional path or sequence of activities that results in the production of a required system-level response from a set of available inputs or stimuli. Thus, a

complete set of CPCIs and CIs would satisfy all the functional and performance requirements of the system. A system defined in this manner would be developed on an incremental basis in which each version/model provides a system capability that is totally operational, rather than in pieces and parts that are only partially operational. Thus versions/models represent functional capabilities and become the milestones of system development.

METHODOLOGY

A comprehensive literature review and semi-structured interview of government and industry "software experts" were used to collect the research data. The existing policies, procedures, guidelines, and criteria for allocation were identified through the literature search. Although the research topic was limited to the selection of CPCIs on a major weapon system that is "software-intensive," over 300 references were identified and evaluated for applicability. Of those, 215 were selected as relevant to this research project. They included Congressional hearings; GAO reports; DOD and AF policies, regulations, pamphlets, and guidebooks; studies; textbooks; periodicals; and "lessons learned." The majority of this published information addressed the acquisition and management of computer resources during the development, acquisition, deployment, and support of major defense systems. Thus, the problems, experiences, lessons learned, and alternative techniques associated with the CPCI selection process were often embedded in the discussions of requirements analysis, system design, software engineering, acquisition management, and software contracting.

The semi-structured interview questionnaire was designed to capture both objective and subjective data from a sample population that included 45 "software experts" from 10 Air Force organizations, 2 Federal Contract Research Centers, and 11 aerospace contractors. The experts were asked to identify and evaluate the criteria used on their acquisition project for making the software requirements allocation decision. Each respondent was asked to identify the impact of the selected CPCI structure on the project. Then, the experts were asked to evaluate the feasibility and perceived effectiveness of "Horizontal Allocation" on the basis of its impact on 12 evaluation parameters. They were: debugging and testing efficiency, maintenance cost, morale of software experts, complexity of software integration, complexity of the allocation process, training effectiveness, cost, development time, performance, management visibility, software quality, and early problem identification. Finally, the respondents were asked to make a recommendation on whether "Horizontal Allocation" should be implemented.

Both qualitative and quantitative analysis techniques were applied to the interview data. The qualitative analysis consisted of categorizing, analyzing, and summarizing the answers expressed by the respondents. Three statistical techniques (Pearson Product-Moment Correlation, Chi-square test and Students' t test) were applied to the quantitative data. In addition, univariate descriptive statistics were calculated for each of the variables.

RESULTS

DOD and AF Policies and Procedures

The acquisition and management of computer resources within the Federal Government are controlled by a complex hierarchy of policies and directives. At the top of that hierarchy is Public Law 89-306 which provides the basic structure and concepts for the government-wide system of Automated Data Processing Equipment (ADPE) management [7]. In the Executive branch, this law has been implemented through the issuance of special rules by the Office of Management and Budget (OMB), the General Services Administration (GSA), and the individual federal agencies. The DOD has issued several directives, instructions, and manuals, and the AF has published two series of regulations, pamphlets, and guidelines dealing with computer resources. They include DOD Directive 5000.29 and the 800-series Air Force Regulations which prescribe the guidelines for acquisition and management of those computer resources integral to a weapon system from a design, procurement, and operations viewpoint; and the 300-series Air Force Regulations which establish the guidance for procuring general-purpose commercially-available ADPE resources. Since the majority of systems classified as "major systems" are weapon systems, this research primarily concentrated on "800-series" acquisitions.

In summary, the DOD and AF policies on requirements allocation state, "Computer resources will be managed as elements or sub-systems of major importance during the system acquisition life cycle [8]." Furthermore, "Computer hardware and software must be specified and treated as configuration items [9]." Although these documents, in general, establish uniform policies and procedures for the implementation of configuration management within

the DOD, the actual application to software is usually recognized as a management decision. Thus, several considerations for use in allocating system requirements to CPCIs are presented in these regulatory publications. They are as follows:

1. The initial CPCI list should contain more items than is anticipated on the final list.
2. Each CPCI should be produced and tested by a single contractor as an entity.
3. Processes that interact strongly should be assigned to the same CPCIs.
4. Processes that will execute in different computers should be allocated to different CPCIs.
5. Processes whose development can feasibly be finished at significantly different times should be assigned to different CPCIs.
6. Include in each CPCI no more than an individual Government monitor can efficiently track.
7. The life cycle cost and management impacts associated with selecting CPCIs should be considered since choosing too few or too many can adversely affect the program.
8. System trade-offs and the natural decomposition of the software should be considered.

These policies and considerations have been interpreted in a few studies, technical reports, conference proceedings, "lessons learned," and guidebooks. Thus, several additional criteria and/or factors to be considered in selecting CPCIs were identified during this research. They are summarized as follows:

1. Each operational program should be a CPCI.
2. Premature "freezing" of system structure into management structure results in efforts being duplicated, system integration becoming more difficult, and overall visibility being reduced as the system design evolves.
3. Software tools should be separate CPCIs; however, resident debug programs are part of the operational CPCI.
4. Decompose the system so that management control and flexibility can be maintained.
5. Partition the system so that implementation, debugging, and testing of modules or groups of modules (CPCIs) can proceed in parallel.
6. CPCIs should be identified on the basis of whether they satisfy an end-use functions, are key programs, have expected interface problems, and will provide added visibility to a particular computer program.
7. The CPCI selection decision should be made early in the program.
8. Include the AFLC system manager in the selection process.
9. The number of CPCIs should be minimized.
10. The end result of choosing a CPCI as a unit of management should be the ability to directly observe that a meaningful portion of the system works. Thus, a structure in which the functional flow across the system is divided into several CPCIs is artificial.

These interpretations have resulted in some discrepancies between the regulations and MIL-STDs. For example, the Defense Acquisition Regulation (DAR) and AFSCP 800-3 consider computer software to be an item of data in the same manner as reports, forms, manuals, and specifications are [10, 11]. Similarly, AFR 800-14 [12] and MIL-STD-483 [13] do not agree on the level of detail required in the Prime Item Development Specification for software.

<u>Selection Criteria Currently in Use</u>

Over 70% of those "software experts" participating in the survey indicated that they were familiar with the criteria used for allocating system requirements to CPCIs on their program. Those criteria most often cited by the respondents were as follows:

1. Software developed by separate contractors/vendors must be separate CPCIs.
2. Functional modularity (i.e., grouping like functions) is a necessity.
3. On-line and off-line diagnostics, and other support software must be separate CPCIs.
4. Each CPCI must operate on a single computer.
5. The number of CPCIs and interfaces must be minimized.
6. Keep the complex interfaces within a CPCI.
7. Off-the-shelf and developmental software must be separate CPCIs.
8. Separate locations and functions require separate CPCIs.

<u>Selection Criteria Deemed Desirable</u>

Several considerations were identified by the respondents as desirable. They included the following:

1. It should be possible to effectively test a CPCI as a whole.
2. Separate users/maintainers should signal separate CPCIs.
3. System performance parameters, such as Maximum Allowable Downtime (MADT) and Processing time (Pt), should be considered in the allocation process.
4. "Politics" among the contractors, procuring agency, using organization, and maintenance organization must be considered.
5. Documentation requirements should be minimized.
6. User and maintainer advocacy should be considered.
7. Size is no longer considered a criterion to be used in selecting CPCIs.

<u>Advantages/Disadvantages of Those Criteria Currently Used</u>

Several advantages and disadvantages of the way CPCIs are presently selected were identified by the respondents. They were categorized by the method of their selection (i.e., contractor chosen, government imposed, previous experience of the contractor and/or program management office, and conformance with the DOD and AF policies and procedures).

In general, there was agreement that those system requirements allocated by the contractors result in a total collection of system software that can be managed in accordance with established Air Force procedures. In summary, the respondents described the following advantages of contractor-selected CPCIs:

1. The Government can hold the contractor responsible for a totally integrated design package, which is available at acceptance.
2. Cost to the Government is minimized.
3. The Government does not accept responsibility prematurely.
4. Programmer assignment is easier.
5. Testing and documenting the system is easier.

On the other hand, the proper application of CPCI selection criteria sometimes requires more knowledge and experience in system acquisition concepts and implications than is brought to bear by the contractors.

At the other extreme (i.e., government-imposed selection criteria/CPCI structure), the disadvantages appear to greatly outweigh the advantages. Only three minor advantages were mentioned by the respondents; while, several negative results were directly attributed to the Government direction. For example, several costly ECPs were required on one program. In another case, completion of the functional qualification test did not allow observation of a working portion of the system.

Although most of the respondents cited previous experience as one of the primary considerations in selecting CPCIs, they did not agree on its utility. For example, experience may lead to an unnatural structure because "it was done this way before" or "the people performing the allocation are unaware of any better technique." Similarly, selection criteria chosen on the basis of experience are hard to clarify and often overlap. This results in independent systems, duplicated functions, and difficult integration problems. On the other hand, criteria chosen in this manner do minimize the problems associated with specification maintenance, testing/requirements traceability, and turnover.

Only 2 of the 37 respondents indicated that the CPCI selection criteria on their program were chosen to conform with the DOD and AF policies and procedures. However, they did agree that the criteria were understandable and worked for most applications, but that all configuration contingencies may not have been considered.

<u>Impacts of the Selected CPCI Structure</u>

The number and composition of configuration items in the acquisition of a major defense system is a critical design issue since the Government's technical management activities primarily focus on CIs and CPCIs. Thus, the need for a CPCI structure that allows management to make realistic conclusions about the cost, schedule, and performance of the final software system cannot be overemphasized.

Over 72% of those Government and industry "software experts" interviewed in this research reported that they had experienced problems with the CPCI structure on their program. In fact, there is sufficient statistical evidence to support the hypothesis that problems are experienced with the CPCI structure on more than half of the major system development/acquisition programs that are software-intensive. Another interesting statistical inference is that problems with the CPCI structure become more prevalent as a program gets larger, both in terms of the number of CPCIs and lines of code.

In many cases, the impact of these problems was devastating to the system development/acquisition program. For example,

schedules were slipped, documentation became confusing, requirements were "lost," ECPs were generated to modify the initial CPCI list, users became frustrated, testing requirements were relaxed, costs increased dramatically, and CPCIs were delivered with a large number of software discrepancies. In at least one case, the impacts were so extreme that the program was cancelled in lieu of trying to salvage it.

Feasibility, Potential Impacts, and Implementation of Horzontal Allocation

Over 82% of those responding to the Software Requirements Allocation Interview indicated that Horizontal Allocation is feasible. In other words, there is sufficient statistical evidence to support the hypothesis that more than half of the "software experts" in the Government and industry believe that horizontal allocation is a feasible methodology for allocating software requirements to CPCIs. This result was significantly correlated (positively) with the size of the development/acquisition program, both in terms of the number of CPCIs and lines of code. Similarly, those respondents who experienced problems with the CPCI structure on their program were more likely to agree that Horizontal Allocation is feasible.

Based on an analysis of the interview results, the potential impacts of defining CPCIs in terms of system versions or models (each of which contains end-use system functional capabilities) were overwhelmingly postive. In fact, there was sufficient statistical evidence to support the hypothesis that more than half of the Government and contractor "software experts" believe that Horizontal Allocation would be at least somewhat effective in favorably impacting all but one of the twelve evaluation parameters. In addition, over 60% of the respondents indicated that this approach to CPCI selection would be moderately to very effective in:

1. providing the program manager and user with more objective visibility into the system development,
2. improving the software quality,
3. reducing the software integration task, and
4. highlighting problems earlier.

Over 75% of those participating in the survey indicated that horizontal allocation should be implemented on future software development/acquisition programs. This result was significantly correlated (positively) with the size of the program evaluated, both in terms of the number of CPCIs and lines of code. In other words, respondents who evaluated large development/acquisition programs believed that this approach should be implemented on future programs.

CONCLUSIONS

The importance of computer hardware and software in the Department of Defense has increased over the past 20 years to the point where computer technology is vital to the defense of our country. In addition, this technology has placed a tremendous strain on the fiscal assets of the DOD and the AF. Therefore, the need to manage computer hardware and software as critical components of a defense system throughout its life cycle is becoming widely recognized. A general awareness of this need was reflected in this survey of Government and industry "software experts," as well as in the literature.

Although the selection of CPCIs is one of the most critical decisions made during the acquisition of a software-intensive system, no known and proven approach was uncovered in this research. On most programs evaluated, functional modularity and previous experience were the primary considerations used by program management offices and contractors to allocate system requirements to CPCIs. This resulted in many problems with assessing development status, achieving system integration, completing meaningful tests and, documenting the system. In essence, managing a program partitioned in this manner forces the program manager to make an inductive evaluation that the system will ultimately work if and only if all other CPCIs work. On the other hand, selecting CPCIs on the basis of horizontal allocation promises to favorably impact the cost, schedule, performance, and management parameters normally associated with an acquisition program.

RECOMMENDATIONS

The following recommendations, if implemented, will lead to a better understanding of the requirements allocation process, and improve the process of developing/acquiring software managed under the DOD 5000-series directives and AF 800-series regulations.

1. A total systems approach to the CPCI selection process is needed. To do this, it is necessary to consider the following factors/questions prior to finalizing the CPCI structure:

a. Advantages and disadvantages of each alternative CPCI structure.
b. Roles and responsibilities of

each participating organization (i.e., user, developer, maintainer, and procurer).

c. Level of management visibility required.

d. Previous experience with a similar type of system.

e. Installation location and functions to be performed.

f. Contractual and legal implications of a CPCI.

2. The confusion and conflict caused by the DAR (ASPR) and AFSCP 800-3 treating computer software as an item of data, rather than an active system component, should be terminated by changing these directives.

3. The discrepancies in AFR 800-14 and MIL-STD-483 regarding the level of detail to be included in the allocated baseline need to be resolved.

4. Since the "software experts" no longer consider size a criteron to be used in selecting CPCIs, it should be deleted [14, 15].

5. The AFR 65-3 definition of a CI (CPCI is undefined in the regulation) should be clarified by changing "end-use function" to "end-use system capabillty." The rationale for this is that the definition as written leads to "vertical" allocation of software requirements to CPCIs. This structure typifies the "black box" approach; and therefore, creates artificial interfaces and an unnatural system architecture.

6. Air Force Systems Command should fund the development of an acquisition management guidebook that addresses, in detail, the system requirements allocation process (for CIs and CPCIs). A comprehensive example, as well as the results of this reasearch should be included. In the meantime, the results of this research should be published and made available to the software industry, as well as those in the Government (procurers, developers, users, and maintainers).

7. Horizontal allocation should be implemented on a medium to small sized program to establish empirical evidence that it is as effective as the "software experts" believe it would be.

8. The survey should be expanded to include a larger number of "software experts" and programs. This would increase confidence in the results achieved and conclusions derived in this study.

9. The applicability of Horizontal Allocation to those software-intensive, general-purpose ADP systems should be determined by a similar research project.

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A TECHNIQUE FOR IMPROVING THE EFFECTIVENESS OF THE LOGISTICS SUPPORT ANALYSIS PROCESS

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ABSTRACT

The logistics support analysis (LSA) process is a substantial improvement over non-analytical methods used in the past by maintenance planners to determine correct maintenance tasks and the resources needed to support those tasks. However, the LSA process, as practiced up to the present date, contains some serious deficiencies that reduce its effectiveness and depreciate its value to Integrated Logistics Support Program Managers, both contractor and customer alike.

This situation points up the compelling need to develop an analysis technique that provides the greatest possible resource definition at lowest possible analytical cost, provides ILS data when and where needed, and reduces paperwork to manageable levels. This paper describes an analytical technique containing the above requisite features.

The technique ranks a set of functionally significant items (FSIs) in a manner that will predict resource requirements, project manpower requirements and assess the impact on equipment operational availability (A_o). This information is provided with the needed accuracy.

INTRODUCTION

The objective of Department of Defense (DOD) Directive 4100.35 is to establish the integrated logistics support (ILS) concept in military acquisition programs as a policy for improving hardware design and material condition. The directive designates the logistics support analysis (LSA) process as a tool to provide the quantitative and qualitative data necessary to meet the ILS requirement.

Since late 1977 the Lockheed-California Company has been actively involved in assisting the Navy in determining and updating preventive and corrective maintenance requirements for U.S. Navy ships. The Lockheed role in meeting the objective of DOD Directive 4100.35 has been to provide an advanced methodology for estimating maintenance resources and to translate those resources into ILS support planning within real world economic and policy constraints.

Problem

A continuing study of existing LSA programs has revealed some problem areas that profoundly affect the quality and usefulness of the analysis output. Quite often, the LSA is regarded as an end in itself rather than a means to meet the ILS objective. Experience has shown that the LSA task can become monumental in a major weapons system acquisition such as a ship or an aircraft when:

- All hardware items are analyzed without regard to the degree of maintenance and functional significance.
- A fixed number of analytical data packages are required for submittal on given due dates without regard to their effect on logistic support.
- An excessive number of support data elements (350 on some items) are recorded for each item analyzed.

With today's approach to corrective maintenance planning, there is no effective means of limiting the scope of analyses or of focusing the analytical effort to obtain high payoff results. It has been found that:

- There is a tendency to analyze everything, thus diluting the use of analytical skills while incurring greater costs.
- There is a tendency to analyze the "easy" items first, because the contractors are paid according to the number of analyses completed. This results in a delay of identification of the really important resources.
- The "analyze everything" approach results in an enormous documentation effort which is very difficult to manage and virtually impossible to keep up to date.

Much of the essential analytical output data becomes available too late to effectively influence the logistic support program because technical data scheduling is based on considerations other than logistic support. This delays the availability of technical data required for early analysis preparation. The late availability of the analysis causes:

- design and construction milestones to be fixed without regard to critical LSA output data, and
- component selections to be made without regard to applicable LSA output data.

At present, there is no technique to cope with the sometimes complex problems associated with an effective integrated logistic support (ILS) program, and a low priority is invariably assigned for the solution of these problems. The need exists for a simple LSA technique and a simple and efficient feedback system.

Background

Lockheed has developed an advanced LSA methodology designed to alleviate the problems under discussion in this paper. One of the important features of the Lockheed procedure is that the analytical steps common to both preventive and corrective maintenance are identified and integrated in the procedure in an organized and effective sequence of events. This arrangement avoids the duplication of analytical effort that occurs when preventive maintenance (PM) and corrective maintenance (CM) are treated as separate programs. It can be seen, for example, that 12 of the 17 functional steps shown in Figure 1 are common to both PM and CM. Only one is peculiar to CM and four are peculiar to PM.

Another important difference between this advanced procedure and other LSA procedures is the addition of a prioritization step involving an analytical technique to provide the greatest possible resource definition at the lowest possible analytical cost. This provides ILS data when and where needed and reduces paperwork to manageable levels.

Purpose

This paper will describe the methods and basic reasoning used in the development of the prioritization technique. It will also discuss the uses of the technique in the planning and management of support resources in an ILS program.

PRIORITIZATION TECHNIQUE

Development

The development of this new methodology began with the detailed study of various LSA procedures used to comply with MIL-STD-1388, AR30, and AMCP 750-16. This study covered systems, subsystems and equipment installed in surface ships, in underwater missile systems, and in both fixed wing and rotary wing aircraft. One of the approaches investigated was the use of a floating cutoff technique. This method limited the scope of LSA by ranking functionally significant items (FSIs) by maintenance action (MA) rates within systems and subsystems, and by ranking failure modes within individual pieces of equipment. The method required that the failures (defective FSIs or failure modes, as appropriate) be listed from highest to lowest MA rate value (see Figure 2).

A relationship was established between the resources and the values in column 3, showing that all the resources needed to support the item being analyzed would be consumed if 100 percent of the failures listed in column 1 were corrected. It follows that the percentage value recorded in column 3 for each failure listed in column 1 also represents the percentage of the total resources consumed if that particular failure were corrected. Based on this rationale, it was felt that an analysis cutoff point could be selected that would always provide maximum resource definition for a minimum of analysis effort. The cutoff was selected at the point where the ratio between two values in column 3 was greatest. However, it was found that use of the floating cutoff technique could obscure the cutoff point if the MA rates were close to the same value. This could result in detailed analysis of all failures identified.

Another technique for limiting the scope of detailed analysis required to determine unscheduled maintenance resources proposed a process for screening FSI failure modes that considered a fixed MA rate value with criticality as determined by a decision logic diagram. A disadvantage of the screening using the safety and operational criticality criterion as proposed was that it only applied at the Organizational level. The items cut from the Organizational level were not eliminated from the analytical effort but were simply transferred to the Intermediate and Depot levels. An additional disadvantage was that the fixed MA rate cutoff technique filtered out all failures in a system whose MA rate was below the cutoff point. Hence, no visibility at all was provided for resource requirements of that particular system.

One important conclusion emerged from the investigations and discussions in all cases where FSI failure mode ranking was a function of MA rate. A few high MA rate items consumed a majority of the resources. For instance, the boiler feedwater system on

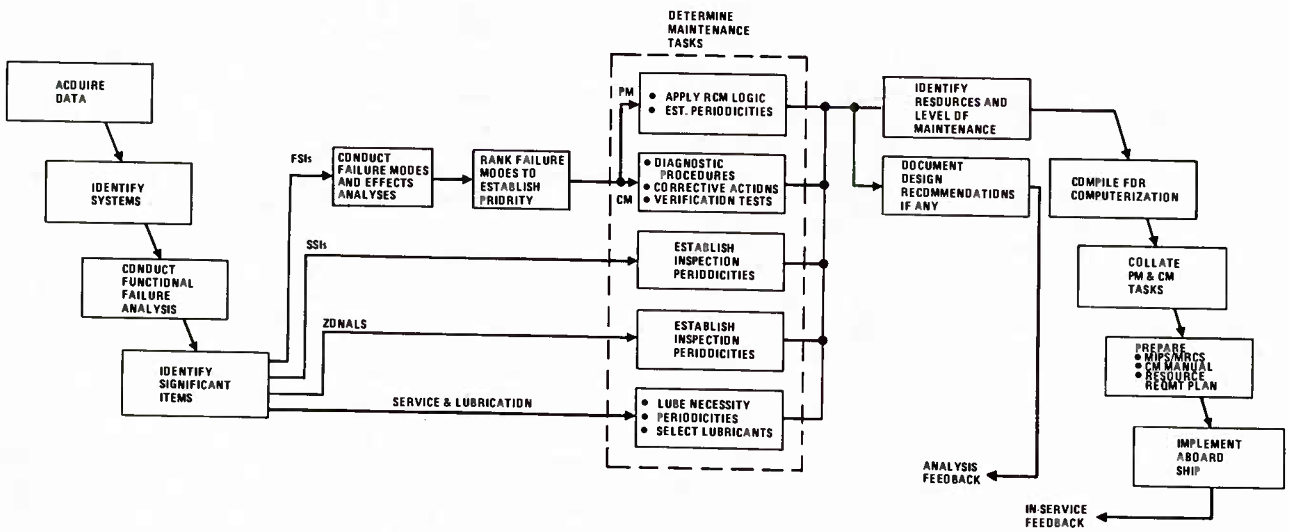

Figure 1. Maintenance Program Development - Overall Process

1	2	3
FSI FAILURE NO. (RANKING USING MAINTENANCE ACTION RATE / FAILURE PARAMETER	MAINTENANCE ACTION RATE PER 1000 STEAMING HOURS	% OF TOTAL
1	0.25	31.6
2	0.22	27.8
3	0.16	20.3
4	0.10	12.7
		CUT-OFF POINT AT DOTTED LINE
5	0.03	3.8
6	0.02	2.5
7	0.01	1.3
TOTAL	0.79	100.0

Figure 2. Failure Ranking With Cutoff Point

the FF-1053 USS ROARK was analyzed in detail to determine resource requirements. Application of MA rate ranking to this system revealed that 27 percent of the failure modes consumed 95 percent of the resources. In another case involving a surface search radar, analysis revealed that 50 percent of the failure modes consumed 94 percent of the resources. In yet another analysis covering an airborne mechanical system, the ratio was 34 percent failure mode coverage for 89 percent resource consumption. Essentially the same ratio between failure modes and resource consumption was observed in the case of multi-level and fixed MA rate screening where MA rate ranking was again used in the procedures. It was mutually agreed that this relationship should be exploited and could become a powerful planning tool if it proved valid across a variety of electronic, weapons, and hull, mechanical and electrical (HM&E) systems.

An example curve was constructed, using data from maintenance engineering analyses with known resource requirements, to graphically show the relationship. A review of this curve revealed that priorities could be established which would have a much more favorable impact on logistics planning than the arbitrary selection of an analysis cutoff point. For instance, the curve in Figure 3 shows that a complete detailed LSA performed on the first 10 of 103 FSIs will define 43 percent of the resources required to support all 103 FSIs within the unit being analyzed. The curve also shows that a complete LSA on the next 10 ranked FSIs would define an additional 39 percent of the resources for a total of 82 percent. LSA on the next 10 ranked FSIs would define an additional 15 percent of the resources for a total of 97 percent of the total resources required to support the unit. However, a complete LSA on the remaining 73 FSIs would identify only 3 percent of the total resources required.

It can be seen that first priority for providing data (technical and historical) and manpower to complete the LSA belongs to the first 10 ranked FSIs, second priority to FSIs ranked from 11 to 20 and third priority to FSIs ranked from 21 to 30. It can also be seen that the same priority can be assigned to parts provisioning, manpower, publications acquisition, training requirements, support equipment acquisition, and facilities planning as soon as the LSA output data is available and the resource requirements are identified:

Three basic questions emerge regarding the prioritization technique:

1. Can this resource requirements curve be forecast from data available early on without performing detailed maintenance engineering analyses on all FSIs?

2. Does the characteristic shape for the curve hold true for all shipboard systems, subsystems and equipment in the electronic, weapons and HM&E technologies?

3. Can the curve be used to forecast the effects of prioritizing on operational availability (A_o)?

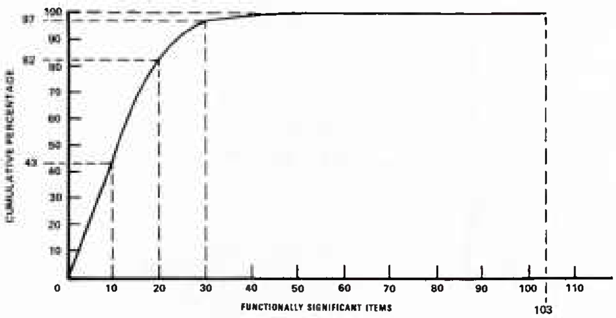

Figure 3. Resource Requirements Curve Ranking

Lockheed has constructed a family of curves based on analytical data developed for two subsystems in the Propulsion Boiler System, and for the complete Surface Search Radar System (AN/SPS-10F). The purpose of this effort was to develop a methodology for constructing the curves and to demonstrate the feasibility of using the curves to provide answers to these three basic questions.

Construction of Prioritization Curves

Five parameters directly related to resource consumption were selected for constructing each family of curves and for ranking the FSIs:

- MA rate
- MA rate times population
- MA rate times population times elapsed time to repair
- MA rates times population times total manhours to rapair
- MA rate times population times cost of spares in dollars

Figure 4 illustrates the correlation of ranking methods for the boiler feedwater control subsystem, and Figure 5 illustrates the correlation of ranking methods for the complete surface search radar system. The solid line in each figure depicts the curve for the MA rate times population parameter and serves as a baseline for comparing the other parametric curve profiles. It is evident from examining the curves in Figures 4 and 5 that a close correlation exists between the curves constructed from the parameters requiring the most detailed analysis and those constructed from the parameters requiring the least detailed analysis. It is also evident that the curve constructed from the MA rate times population data may be used to forecast the resource requirements

curves with a high degree of accuracy, thereby providing a positive answer to the first question posed regarding the prioritization technique. This is illustrated in the example shown in Figure 4. Curve B, representing the MA rate times population parameter, can be constructed from data obtained from the Failure Modes and Effects Analysis (FMEA). The FMEA requires about 30 percent of the effort needed for a complete detailed analysis for a system or an FSI. Curve B also shows that data from the FMEAs for six of 22 FSIs will forecast 96 percent of the resource requirement identity. Complete detailed analysis shows a resource requirement identity of 94 percent with elapsed repair time known, 95 percent with elapsed repair and total manhours to repair known, and 89 percent with elapsed repair time, total manhours to repair and dollars known. A similar relationship can be observed in Figure 5.

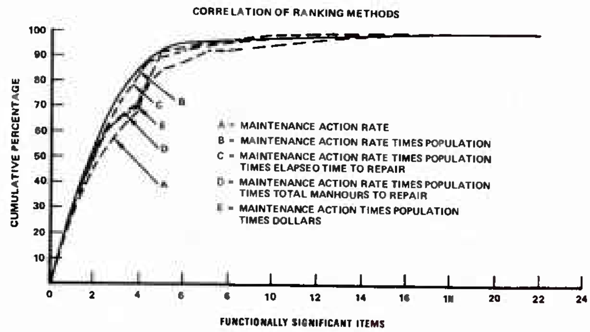

Figure 4. Boiler Feedwater Control Subsystem Curves

The foregoing ranking relationship and the substantiating data, in the form of other related families of curves for subsystems in the propulsion boiler system and in the surface search radar system, provide ample evidence that the MA rate times population curve can indeed be used to forecast resource requirements for the HM&E and the tube type electronic systems analyzed.

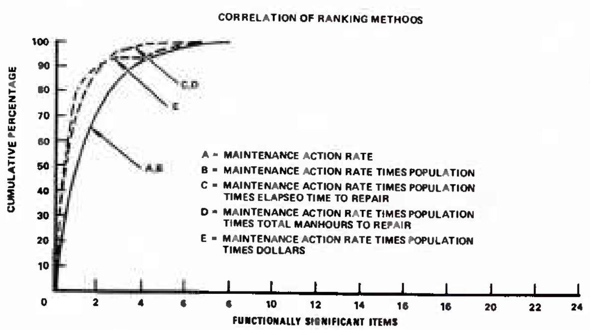

Figure 5. AN/SPS-10F Surface Search Radar Curves

Another family of curves was constructed using the same parameters as before for a weapons system and a solid state electronics system, to ensure that the forecasting technique would apply across a broader cross section of shipboard technologies.

The 5-inch 54-caliber gun mount gun loading system and the AN/AQA-7(V) DIFAR processor were selected as representative of their respective system types. The results of the additional analysis are shown in Figures 6 and 7.

The close correlation between the ranking methods can again be observed, indicating that wide diversity in the design and function of systems and equipment has minimal effect on the relationship between resource requirements and failure ranking by MA rate times population. It is evident from inspecting Figures 4 through 7 that any significant divergence of the resource requirements curves (dashed lines) from the planning forecast curve (solid line) occurs in the highest MA rate area (steepest slope of the curves). This characteristic of the prioritizing technique is very useful since it provides the support planner with early visibility on any significant problems emerging in the support program. For instance, a high value cost, repair time or manpower figure multiplied by a high MA rate value results in a significant steepening of the affected curve. The curve can be used by the planner during the design phase as justification to request an improvement in maintainability or reliability features through design change in order to alleviate a potential support problem.

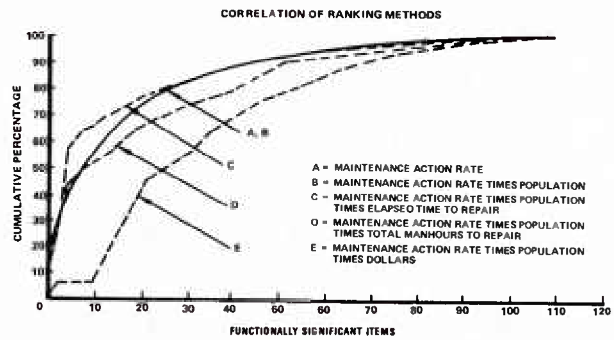

Figure 6. Gun Loading System (Combined FSI Ranking)

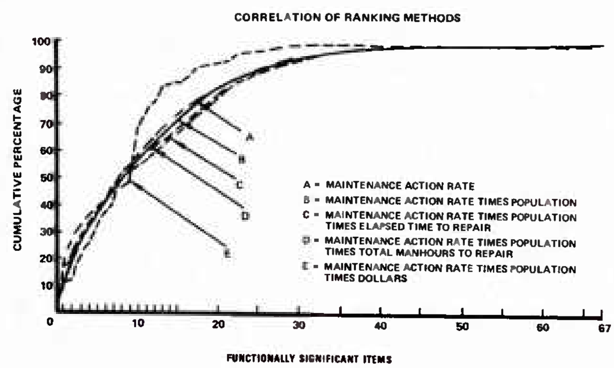

Figure 7. AN/AQA-7(V) DIFAR Processor (Combined Subsystem Ranking)

As a result of these findings, it was concluded that an MA rate times population curve was an accurate and reliable predictor of resource requirements and could be used with confidence in support planning, not only to forecast resources but to establish priorities for subsequent detailed analyses and funding requirements for logistics support.

A series of curves was constructed to show the relationship of the planning forecast curves (MA rate times population) for the four systems analyzed (see Figure 8). It can be seen that a close correlation is maintained between widely diversified systems as well as

between elements within the same system, as shown in Figures 4 through 7. The dashed lines show that the analytical effort needed to identify 90 percent of the resources varies from approximately 27 percent at the low end to approximately 58 percent at the high end.

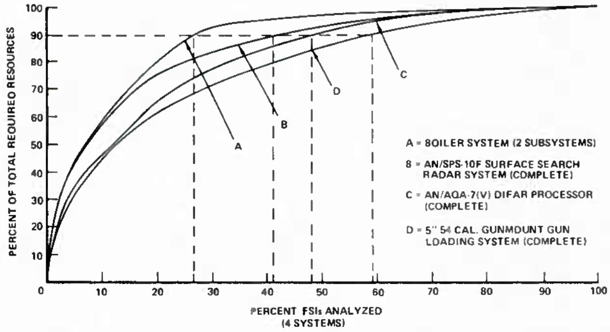

Figure 8. Percent FSIs Analyzed (4 Systems)

The work done in the area of operational availability (A_O) and the interaction between A_O and maintenance engineering analysis was also an important factor in the development of the prioritization technique. Mean time between maintenance actions (MTBMA) and mean time to repair (MTTR) are two important factors generated by maintenance analysis which are required in the calculation of A_O. The MTBMA parameter is obtained from the FMEA, but the MTTR value is obtained from the task definition, which often requires extensive analysis effort beyond completion of the FMEA. It can be shown that the failure ranking technique offers considerable potential in the forecasting of A_O without extensive analysis.

An A_O forecasting method was needed which would only require limited engineering analysis and which would interact with and enhance the utility of the prioritization curves in the maintenance planning process.

A curve was developed by making two important assumptions and by using data obtained from the FMEA. The assumptions are:

- If logistic support is provided for the FSI and the FSI is not otherwise coded for off-ship remove-and-replace maintenance action, a minimum amount of supply response time is assumed, such as 4 hours.
- If logistic support is not provided for the FSI or if the FSI is coded for off-ship remove-and-replace maintenance action, a significant supply response time is assumed, such as 288 hours.

Using the above supply response time (MDT) assumptions, A_O was calculated for the AN/SPS-10F Surface Search Radar using the equation

$$A_O = \frac{MTBMA}{MTBMA + MTTR + MDT}$$

Figure 9 is a graphic display of the results for the radar. The curve is plotted according to the following logic. For point A, 4 hours MDT is assigned to the highest ranking FSI, assuming it is the only one supported at the Organizational level. All other FSIs are assigned 288 hours MDT. For point B, 4 hours MDT is assigned to the two highest ranking FSIs and 288 hours to the others. The process continues until at point C all FSIs are supported with an MDT of 4 hours. For the A_O forecast curve, the value of A_O is plotted as a percentage of A_I where

$$A_I = \frac{MTBMA}{MTBMA + MTTR}$$

If an FSI is not coded for Organizational level, remove-and-replace always has an MDT of 288 hours.

As a result of the A_O curve development work, it was generally agreed that the planning forecast curve could be used to forecast the effects of prioritizing on A_O. The procedure for obtaining this information will be discussed in the following section.

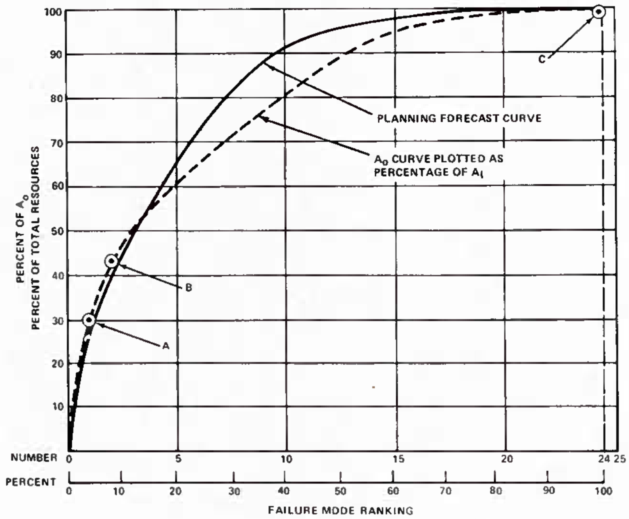

Figure 9. Operational Availability Forecast Curve

Using the Prioritization Technique

The prioritization process is initiated by preparing a forecast planning curve for the maintenance of the significant item (system, subsystem, equipment) being analyzed, using functional failure analysis (FFA) and failure modes and effects analysis as appropriate. FFA and FMEA documentation is normally available sufficiently early in an acquisition program to prepare the curves for use by logistic planners during the design phases.

Curves continue to be developed throughout the design and development phases until design maturity is reached. They are updated as necessary during the production and deployment phases as feedback data from actual operations become available. New curves are generated as required to support hardware changes resulting from SHIPALTS, ORDALTS and Field Changes. The FFA and FMEA data are recorded and processed on a failure mode ranking table (see Figure 10). The processed information from the table is then used to construct the curve.

Construct the curve by plotting the cumulative percentage (0 to 100) from the right column of the failure mode ranking table

(Figure 10) on the ordinate (vertical axis) versus the ranking from the left column of the same table on the abscissa (horizontal axis). Add a second percent reference scale (0 to 100) along the abscissa (divided into 10-percent increments) where 100 percent coincides with the lowest ranked item in order to determine the percentage of total items ranked for any given point on the curve (see Figure 11).

RANK NO.	FAILURE MODE	MAINT. ACTION RATE	QTY	MAINT. ACTION RATE X QTY	PERCENT TOTAL FAILURE MODE	CUM PCNT FAILURE MODE X QTY
1.	Receiver and Radar AFC	1.55	1	1.55	28.8	28.8
2.	Thyratron Tube Chassis	.55	1	.55	10.2	39.0
3.	Power Supply Tube Chassis	.55	1	.53	9.9	48.9
4.	Magnatron	.48	1	.48	8.9	57.8
5.	Mixer Assy.	.45	1	.45	8.4	66.2
6.	Trigger Pulse Generator Chassis	.36	1	.36	6.7	72.9
7.	Amplifier Chassis	.32	1	.32	6.0	78.9
8.	Radar Modulator	.27	1	.27	5.0	83.9
9.	Voltage Regulator	.25	1	.25	4.7	88.6
10.	Radar Receiver Transmitter	.21	1	.21	3.9	92.5
11.	Rectifier Chassis	.09	1	.09	1.7	94.2
12.	STC Chassis	.07	1	.07	1.3	95.5
13.	Power Supply Chassis	.06	1	.06	1.1	96.6
14.	T.R. Tube	.05	1	.05	.9	97.5
15.	Shutter Motor	.03	1	.03	.6	98.1
16.	Antenna Subsystem	.03	1	.03	.6	98.7
17.	Pretrigger Generator	.02	1	.02	.4	99.1
18.	Synchro Transmitter	.02	1	.02	.4	99.5
19.	Power Supply Subsystem	.01	1	.01	.2	99.7
20.	Regulator Control Assembly	.01	1	.01	.2	99.9
21.	Auxiliary Control Panel	.009	1	.009	.03	99.93
22.	Antenna Drive Motor	.006	1	.006	.02	99.95
23.	Bearing Selector Switch	.004	1	.004	.02	99.98
24.	Interconnect Box	.003	1	.003	.02	100.0

Figure 10. Failure Mode Ranking Table

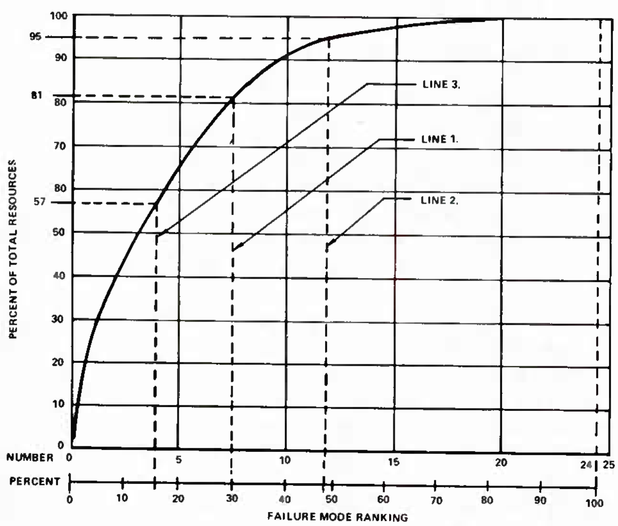

Figure 11. Planning Forecast Curve

The curve may be used for both PM and CM, as applicable, to forecast the following maintenance support elements using the data recorded in the Failure Mode Ranking Table:

- Resource Forecast – Provides estimate of contribution of each failure mode to total resource requirements, in advance of actual determination of those resources by subsequent detailed analysis.
- Forecasting Maintenance Manpower Requirements – Allows prediction of total manhour requirements from data developed from limited failure mode analyses.
- Forecasting Operational Availability (A_o) – Provides estimate of A_o as percentage of A_I (inherent availability) that would result from satisfying the resource requirements reflected by a given point on the planning forecast curve or the resource requirements curve.

To estimate the resource requirements as a percentage of total requirements needed to restore functions lost by a given percentage of failure modes:

1. Select failure mode percentage from percent scale along abscissa.
2. Extend vertical line to intersect curve.
3. Extend horizontal line from point of intersection on curve to resource percentage scale at ordinate.
4. Read corresponding resource percentage from ordinate scale (see Line 1, Figure 11).

To determine number or percentage of defective failure modes that contribute to a given percent of total resources:

1. Select percentage of total resources number from ordinate.
2. Extend horizontal line from point selected on ordinate to point of intersection on curve.
3. Extend vertical line from horizontal line intersection point on curve to number and percent scales along abscissa.
4. Read desired number of percent value at vertical line and appropriate scale intersection point (see Line 2, Figure 11). For 95 percent at the ordinate read 12 on number scale and 48 percent on percent scale at abscissa.

To estimate resource requirements as percentage of total requirements for a given number of failure modes (4, for example):

1. Enter the number scale along abscissa with 4 failure modes.
2. Extend vertical line to intersect point on curve.
3. Extend horizontal line from vertical line intersection point to the percent scale along the ordinate.
4. Read the resource percent at horizontal line intersection point (see Line 3, Figure 11). For item 4 on number scale at abscissa, read 57 percent at ordinate.

To forecast manpower requirements:

1. Enter the number scale along abscissa with the number of failure modes being considered (see Figure 11).

2. Extend vertical line to curve from that number of failure modes.

3. Extend horizontal line from vertical line intersection point on curve to percent line on the ordinate. Record percent reading.

4. Sum manhour requirements for the number of failure modes selected in Step (1).

5. To estimate total manhours, divide manhour value from Step (4) by percent value recorded in Step (3). Convert percent figure to decimal equivalent (e.g., 50 percent = 0.50; 97 percent = 0.97) before dividing.

For Line 3:

Enter number scale on abscissa at 4. Read 57 percent at the ordinate. Assume a hypothetical 13.5 manhours required to restore the four failure modes.

$$13.5 \div 0.57 = 23.7 \text{ total manhours predicted}$$

For Line 1:

Enter number scale on abscissa at 8. Read 81 percent at ordinate. Assume a hypothetical 18.8 manhours required to restore the eight failure modes.

$$18.8 \div 0.81 = 23.2 \text{ total manhours predicted}$$

For Line 2:

Enter number scale on abscissa at 12. Read 95 percent at ordinate. Assume a hypothetical 21.5 manhours required to restore the twelve failure modes.

$$21.5 \div 0.95 = 22.6 \text{ total manhours predicted}$$

To forecast operational availability for a given resource percentage:

1. Calculate A_o as follows to plot curve:

$$A_o = \frac{\text{MTBMA}}{\text{MTBMA} + \text{MTTR} + \text{MDT}}$$

MTBMA (Mean Time Between Maintenance Actions) = 1000 divided by value from Maintenance Action Rate column in Failure Mode Ranking Table (Figure 10).

$$\text{MTTR (Mean Time to Repair)} = \frac{\Sigma(\text{ET})(\text{MA RATE})}{\Sigma \text{MA RATE}}$$

ET = Elapsed Time for failure mode being considered from task data sheet.

MA RATE = Maintenance Action Rate from Failure Mode Ranking Table.

MDT (Mean Delay Time) = 4 hours for "O" level tasks, 288 hours for off-ship tasks.

2. Plot A_o points for each calculated value. Superimpose the A_o curve on the planning forecast curve (see Figure 12). The A_o curve depicts A_o as a percentage of inherent (or designed) availability (A_I).

To determine the A_o value for a given resource forecast percentage value:

1. Select resource percentage from ordinate.

2. Extend horizontal line to planning forecast curve.

3. Extend vertical line from intersection point of horizontal line with planning forecast curve to A_o curve.

4. Extend horizontal line back to ordinate from intersection point of vertical line with A_o curve, and read A_o value in percentage of A_I. Using Line 1, Figure 12 as an example, supplying 65 percent of the total resources yields an A_o value representing 61 percent of the achievable A_I. The example also illustrates that the A_o forecast value can be determined by performing detailed task analyses on 5 FSIs or 20 percent of the total FSI count in the example.

To determine resource forecast and analysis effort needed to achieve a given A_o value:

1. Select A_o value at ordinate.

2. Extend horizontal line to A_o curve.

3. Extend vertical line intersection point of horizontal line with A_o curve to planning forecast curve.

4. Extend horizontal line back to ordinate from intersection point of vertical line planning forecast curve and read resource forecast value (see Line 2, Figure 12). In this example, an A_o target value of 72 percent of the achievable A_I will require 82 percent of the resources.

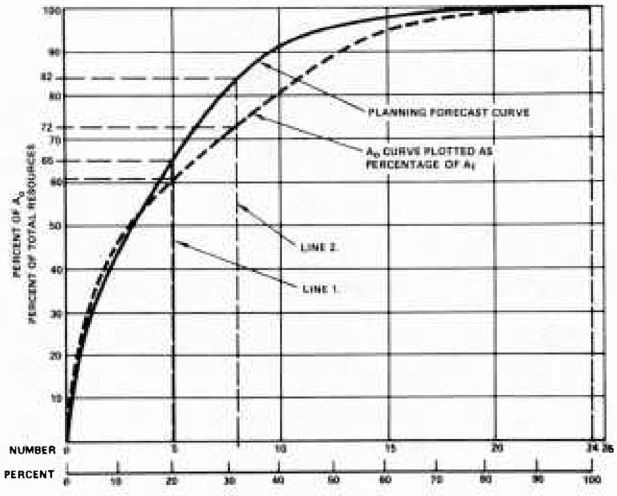

Figure 12. Operational Availability (A_o) Forecast Planning Interaction

5. Extend vertical line from 72 percent on the A_O curve to number and percent scale along abscissa, and read number and percent of FSIs requiring detailed task analysis to achieve given A_O value. In this example (Line 2, Figure 12), an A_O target value of 72 percent will require detailed task analysis on 8 FSIs or 32 percent of the total FSIs in the example.

An investigation was conducted to determine the technical manual impact of the application of the prioritization technique on a system which had been analyzed and on which the technical data had been determined. The results of this study are shown in Figure 13.

The prioritization curve for the AN/SPS-10F Surface Search Radar shows that 95 percent of the resources required to support the system can be identified by performing maintenance analysis on 50 percent of the significant items defined. The effects of this reduction in analysis and consequent reduction in maintenance tasks on the technical publications costs can be seen in Figure 13. The significant item count in the existing manual column and the hours for preparation of technical information are estimated based on existing manual coverage of significant items as defined by Lockheed. It should be noted that the percent reduction in these two areas is conservative when compared with actual finished page count. The technical hours are based on 55 hours preparation time per significant item. This table does not include the 204 pages in the Navy overhaul manual for the radar, which Logistic Support analysis indicates is not necessary.

Comparison Item	Existing Manual	Prioritization Method	Percent Reduction
Significant Item Count	134	24	82.0
Page Count	602	79	86.9
Technical Hours	7,370	1,320	81.4
Production Hours	4,595	572	87.6
Printing Costs in Dollars	2,047	287	86.0

Figure 13. Maintenance Manual Cost Comparison Table

CONCLUSION

This paper has described an analysis technique designed to provide maximum support resource identity at minimum analysis cost. This technique provides the quantitative and technical data generated by the analysis when and where required and maintains the paperwork at manageable levels.

The technique includes preparation of a planning forecast curve which accurately predicts resource requirements in a ranked set of functionally significant items (FSIs). It has been amply demonstrated that the prioritization concept is sound and applies across widely diversified shipboard systems as well as within functionally similar systems and FSIs. The examples cited in this report show that manpower requirements can be projected with reasonable accuracy using the prioritization technique. The effects on A_O of satisfying or not satisfying resource requirements can also be forecast with reasonable accuracy, once the A_O values have been determined for a given set of FSIs, or accumulated in major systems from directly related or interacting systems and subsystems.

Application of the prioritization technique results first in a planning forecast curve and then in a resource requirements curve. Consequently, LSA is performed first on the high priority failures identified by the planning forecast curve. This concept, therefore, provides a practical means for limiting both PM and CM analysis to those FSIs requiring the greatest amount of resources. However, analyzing the more important items first does not prevent 100 percent LSA for a given set of FSIs, but rather it allows an intelligent selection of those items in the event that the LSA must be limited because of time, manpower, or dollar constraints.

It may be beneficial in some PM analyses to have early identification of those tasks which have the highest impact on resources, regardless of other considerations such as criticality. The prioritization concept established by the planning forecast curve provides that information, particularly when PM and CM analyses are being performed by the same analyst. In the case of PM, the priorities established by the planning forecast curve may sometimes be preempted at the planner's or analyst's discretion. For example, a detailed PM task analysis may be required regardless of the planning forecast curve priorities when a failure would result in a critical safety situation.

Examples in this report have shown that the prioritization technique reduces the cost and quantity of technical data needed to support a given FSI or set of FSIs. This is accomplished by developing only the amount of technical data needed to support the items that are high-failure, high-resource users up to the limits designated by support program managers. The managers are in turn guided in their decisions by the applicable planning forecast curves. The limited data is provided to maintenance personnel charged with the support for the items covered.

Items with low failure rates are typically eliminated by the planning forecast curve screening process. It is proposed that these items be handled through a maintenance control center with access to more detailed support documentation with limited distribution. The maintenance center would be manned by experts in the various shipboard technologies and would maintain open lines of communication with fleet operating units to disseminate the information as needed. This control center concept includes access to other rarely used resources such as spares, support equipment and training for support of those items at the low failure rate end of the planning forecast or resource requirements curve.

The application of the methodology described in this report will reduce equipment downtime at all levels of maintenance by reallocation of resources. An effective maintenance program must place resources in a position to correct failures when and where they occur as predicted by the planning forecast curve in the design and development phases of a weapons system acquisition and as directed by the resource requirements curve during the operation and deployment phases. Equipment downtime can be reduced at the Organizational level by focusing the direct manhours and skills, spares, support equipment, and documentation to correct those shipboard failures with greatest resource need and largest impact on A_O. The same logic can be applied to reducing turnaround time at the Intermediate and Depot levels by planning for failures with short failure intervals and high resource consumption on a priority basis as dictated by the resource requirements curve for the equipment being repaired. Long term benefits from the prioritization technique will largely depend on an adequate feedback system to accurately identify candidates for product

improvement such as high resource users and contributors to low A_O, and on the updating of maintenance plans and resource requirements as indicated by feedback reports.

RECOMMENDATIONS

The following recommendations are provided to maximize the benefits inherent in the prioritization concept:

- Develop an adequate technical and historical data base
- Develop a functional system breakdown as opposed to an operational block diagram or a drawing breakdown of the "bill-of-material" type
- Select functionally significant items in accordance with approved definitions to ensure effective item screening and uniformity of analysis
- Define functions, functional failures and failure modes carefully to ensure uniformity of analysis
- Ensure that the prioritization process is scheduled properly during the LSA to provide timely availability of data
- Develop an adequate data feedback system in order to update analysis to reflect actual operating conditions

ACKNOWLEDGEMENT

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AVOIDING THE COSTLY PITFALLS OF ENGINEERING DOCUMENTATION FOR HIGH RELIABILITY PARTS USED IN MILITARY SYSTEMS

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ABSTRACT

Each year the Department of Defense and its contractors spend billions for engineering documentation in the form of specifications, drawings and test data for high reliability parts used in military weapon systems and support equipment. Much documentation can be avoided and is probably already available elsewhere in government. This paper shows how to avoid the costly pitfalls of redundant documentation for high reliability parts by applying parts control techniques in the early phases of equipment development. The paper describes the benefits of parts control techniques and the utility values of standards when applied in DoD contracts. The authors discuss new standardization techniques to prepare accurate documentation within shortened schedules. Emphasized is the monetary payoff of parts control when life cycle cost impacts are examined.

INTRODUCTION

Each year DoD buys about $2 billion worth [1] of engineering drawings, technical manuals, specifications, test reports and other kinds of data. Much of the cost of this data can be avoided if the technical bureaucracy could re-use prior engineering decisions made in the form of standards and military specifications tailored to the needs of specific acquisitions. Unnecessary documentation for piece parts is an area directly impacting the affordability of military equipment. As an example, in the electronics area alone, between 50,000 and 100,000 new nonstandard electronic piece parts are processed for logistic support each year. [2] Depending upon the complexity, uniqueness and end item application of a particular device type, the DoD cost in systems acquisition to document and test each electronics part type ranges from a few hundred dollars to $30,000, [3] with an annual cost impact ranging between 300 and 600 million dollars. The operations and support for these same electronic items is estimated to add a ten year DoD supply management burden of between 90 million and 180 million dollars (this excludes the cost of the parts). New nonstandard items of unproven reliability also impact the performance of electronic equipment in the field and can drive upward the costs of maintenance.

Recent DoD studies estimated the annual DoD cost for maintenance of the electronics in-use inventory to be $6.1 billion. Because of the proliferation of parts documentation and growth in the supply inventories for electronic parts, an experimental parts control program conducted at the Defense Electronics Supply Center (DESC) in the early 70's revealed the re-use of existing engineering data for electronic parts could yield significant savings to the DoD. The DoD Parts Control Program, using the technical services of engineers within the Defense Logistics Agency (DLA), was formally established in 1973 with DESC engineers designated a role as Military Parts Control Advisory Group or "MPCAC" (pronounced Mip-Cag). While the parts control effort is largely oriented to electronic systems (67% of the parts evaluated are in DESC supply classes) the subsequent establishment of three other MPCAGs within DLA gives the military services' acquisition managers a total DLA team support in selecting standard parts in the early phases of system acquisition.

THE EXPLODING ELECTRONICS TECHNOLOGY

Rapid changes in the design of electronic gear have created a phenominal proliferation of electronic piece parts such as integrated circuits, transistors, diodes, thyristors, resistors, capacitors, switches, transformers, coils, filters, connectors, etc. Systems application of this complex equipment is demanding higher performance and reliability from the standardization of the working components.

In an article in the Defense Management Journal, Mr. W. F. Rockwell, Jr., Board Chairman of Rockwell International Corporation, said: "Contracts with the Defense Department impose various requirements upon the contractor...of all the imposed requirements, there is probably none as mutually beneficial to both the customer and the contractor as the requirement for standardization." Mr. Rockwell states further in the article: "To be successful, standardization must be designed into the aircraft from the very beginning. This means designers must have adequate parts and practices documents at his fingertips when he begins his design" [4]

A weakness in the DoD Standardization program has been the lack of a method to ensure the uniform application of standard parts in acquisition programs. Many studies were made on what to do about the expanding investment in logistic support

for electronic parts and the very serious problem of keeping equipment operational while avoiding the high costs of maintenance. The common thread flowing through these reports was that standardization efforts must be concentrated during design and applied in a consistent manner and documentation for parts kept up to date to meet the demands of technology. The major roadblock to this approach would be the equipment designer - - will he use standard parts? Experts are now convinced that the equipment designer will use standard parts provided he can:

(1) Conveniently determine which available standard parts will meet his required applications.

(2) Easily communicate his electronic parts needs to a knowledgeable parts specialist and receive a fast response.

(3) Be assured that controls for component selection and use of standard parts will not stifle his freedom of choice and compromise his circuit design.

(4) Keep his project on time and within cost.

Standardization at the design level has to be enforced if costs associated with parts documentation are to be reduced. Someone once said that "Standardization relegates to the field of routine those problems which have already been solved and allows valuable time to be spent on creative investigation."

It has become an objective of the Parts Control Program to assure that conditions are met for the equipment designer to use standard parts. This is accomplished by providing timely changes to military documentation to include current technology parts and assuring that MPCAG electronic engineers are available to discuss specific parts problems.

The active involvement of standardization engineers in the review of nonstandard parts at the design stage is proving to be a valuable asset to the military departments. The analysis of parts application trends provide the government a tremendous potential for design documentation standardization that was previously impossible to obtain. For example, under the DoD Parts Control System program, the MPCAG continuously collects and evaluates all data describing nonstandard parts approved for use in military equipment. Knowing the program application (space, air, sea, ground) is instrumental in detecting trends in the use of electronic parts. The automation of information through the MPCAG computer program instantly identifies if, when, and where a proposed nonstandard part had been previously seen by MPCAG engineers. Data stored can then be reused to update documentation to current technology and application on other acquisitions.

<u>Individualism Can Drive Costs</u> Each of the military services and elements within the departments have developed their own techniques to control parts in new design. However, very few acquisition managers have the expertise or resources to control or interface the selection and use of high reliability parts among their contractors. For many years, engineers at DESC have supported the services in the development and issuance of military specifications for high reliability parts such as "established reliability" (ER) resistors, capacitors, connectors, coils; "extra screening" (TX) transistors and diodes, and high reliability micorcircuits specified to MIL-M-38510 and tested to MIL-STD-883. Under the new DoD Parts Control System (DoD Instruction 4120.19), a uniform way is provided for acquisition managers to use MPCAGs to obtain maximum effectiveness. The program is designed to provide a useful service by permitting DoD contractors to use the MPCAGs for recommendations on the selection of parts. The engineers at DESC are able to provide such a service because of their electronics background gained from many years of experience in the standardization and testing evaluation of electronic items (There are 70 engineers and 60 technicians available for this function in DESC's Directorate of Engineering Standardization.) We should note here that the MPCAG only recommends what parts should be used -- the actual decision on what part will be used, or not used, remains with the military procuring activities. This valuable resource can be instrumental in saving millions of dollars annually by showing how existing standards documentation can be applied on defense programs. Individual military department regulations now require the use of MPCAGs on most design contracts.

<u>What is Standard?</u> Depending upon whom you ask the question, the idea of a "standard part" varies. A government logistician may claim that a standard part is any item which has a National Stock Number (NSN). An original equipment manufacturer may claim that any item is standard which was previously approved for use in one of his govenment contracts. The specification writer may state that a standard part is one described to the requirements of a government specification. A standards engineer may define a standard part as one of the types so described in his standard publication. MIL-STD-965 Parts Control Program says that a "standard" part is that part which is defined as such in procurement documentation for a particular equipment or system design contract. Thus, the criterion for a "standard" part conveys both misunderstanding and confusion to the government contractor who is developing electronic equipments for more than one DoD acquisition activity.

The confusion adds to the creation of new documentation and more product testing for many common items previously tested and described in specifications or documentation acquired in earlier contracts. We find the reason for the documentation and testing of nonstandard parts is the need for assurance by the military services and the contractor that electronic parts will perform satisfactorily in a military system application.

A cursory review of drawings for nonstandard parts shows that reliability requirements are paramount. Usually such documents reference

quality assurance procedures or testing methods covered by military specifications for comparable standard parts. MIL-M-38510 for microcircuit quality and MIL-STD-883 for microcircuit test methods are but two examples. In the electronics area, electronic parts described to high rel military specifications are generally referred to as "standard" parts in most design applications.

Getting A Handle on the Documentation Problem
Until MIL-STD-965 was issued, procedures for obtaining approval to use "nonstandard" high reliability parts varied among and within the military services and other government agencies. The prevalent method described in most general specifications for electronic equipment was MIL-STD-749, "Preparation and Submission of Data for Approval of Nonstandard Parts." Under this technique the contractor researched for available standard parts that were capable of sustained operation under the environment in which the parts were placed within the prime equipment. When he could not find a "standard" (by contract definition) to meet his application, he started with what was called Step I to justify the use of a nonstandard part.

The justification required a comparison of the part with a standard part which had characteristics nearest to those required for the application. The justification was then submitted to the appropriate procuring activity (or parts support activity specified in the contract) for approval. A 30 day turn around time was usually specified for the nonstandard part approval process. (The MPCAG has to perform the nonstandard part review in seven working days.)

After review of the nonstandard part justification, and if use of the part was approved, the approving agency informed the contractor whether or not to proceed with Steps II and III. Step II required the contractor to prepare a drawing or specification that defines electrical parameters, environmental and quality assurance testing requirements, etc. Step III asks for the submission of test data to provide evidence of compliance with the requirements of the specification or drawing of the nonstandard part.

All documentation required by Step II and Step III were to be submitted to the procuring activity for approval/disapproval within 30 days. To save time, many military electronic equipment specifications using parts approval procedures of MIL-STD-749 required that Step I and Step II be accomplished simultaneously.

The technique described in MIL-STD-749 was identified as a major documentation cost driver in DoD contracts. In addition, the military services did not have adequate resources to thoroughly review all the documentation called for. The standards engineer became part of the problem rather than a solution since there was never enough time to get through the huge papermill generated by MIL-STD-749. The GAO reported that one activity required 117 days to process a nonstandard part approval request. In the same report, the GAO reported that the government pays $500 to $8000 for nonstandard part documentation and up to $25,000 for testing to insure an item meets reliability requirements! [5]

MIL-STD-965 reduces costs and shortens approval time by permitting contractors to use MPCAGs for advice on the use and availability of standard or preferred parts.

The Ramification of "Going Commercial" Can we solve the problem of high costs for parts documentation in weapon systems by buying items with no documentation? The buying commercial philosophy looks very attractive on the surface. [6] However, it should not be considered a panacea and cause to cancel military specifications that are used daily on a very cost effective basis. While buying commercial is fine for common electrical hardware supplies, we must proceed with care before applying the commercial buy technique to electronic parts.

The key to the use of commercial products in weapon systems is to determine "when such products will adequately serve the government's requirements." Experts in the field of electronics design claim that commercial grade electronic items do not meet the performance requirements dictated by the needs of our weapon systems.

Quoted below are several indications why high reliability electronic parts of military grade are essential for use in government systems subjected to severe environments:

---"A key ingredient in achieving the F-15 levels of reliability is the high-reliability parts control and standardization program.------ Established Reliability (ER) capacitors and resistors, tested extra (JANTX) transistors and diodes, and integrated circuits selected through "MIL-M-38510 and screened to MIL-STD-883 Class B level, are emphasized.---" [7]

---"64% of the commercial transistors were rejected during in-house screening, which was indicative of the relative incoming quality levels of the transistor. The choice of commercial parts with low initial acquisition cost can, during the life of the equipment, result in a higher life cycle cost due to the higher expected number of failures and the relatively high cost of repair and retest ---." [8]

---"In a cost constrained program, there is the pressure to lower part quality and initial procurement costs------. What may seem to be a "low cost" approach, therefore, may prove to be costly should high reject rates be experienced either during screening of the parts or hardware acceptance tests." [9]

---"The non-MIL Class B screened microcircuit removals or fallout were 2.73 times the number of removals experienced for MIL-M-38510 Chass B microcircuits. A major factor contributing to this nearly triple non-MIL microcircuit fallout is attributed to lower quality due primarily to

procurement specification and surveillance differences---." [10]

---"DoD publishes standards and specifications on a number of standard integrated circuits using MIL-M-38510 as a vehicle. Contracting methods now encourage systems developers not to use these parts because they receive G & A and profit for nonstandard part specification preparation and qualification." [11]

We support the concept of using commercial products --- when such products satisfy requirements of the design application. However, the very reason we pay so much for parts documentation is the poor track record of commercial type electronic items applied in new weapons design. When cost effective, we should continue to maintain and strengthen the use of DoD specifications (including adopted industry documents) wherever possible. Before deciding to go commercial, the acquisition manager must carefully weigh the risks. The added cost of using hi-rel standard electronic parts may well be worth the increased performance and decreased operation and support costs.

The Need For Documentation Some form of documentation is critical if an item is to be procured and stocked to the same quality levels as an identical item designed into the equipment. At DESC for instance, a large file of drawings has been established to procure items.

To illustrate the degree of documentation redundancy that has developed over the years, there are more than two million drawings on file to describe 400,000 items, a ratio of five documents for one stock number! The advantage of using standard items is quite evident when we observe but 6,000 military specifications are used to procure more than 120,000 standard items, a ratio of one document for 20 stock numbers. (See figure 1.) Using a minimum engineering resource (DoD or contractor) investment of $1500 per drawing, the cost of the drawings is in excess of $3 billion as compared to $9 million for the specifications!

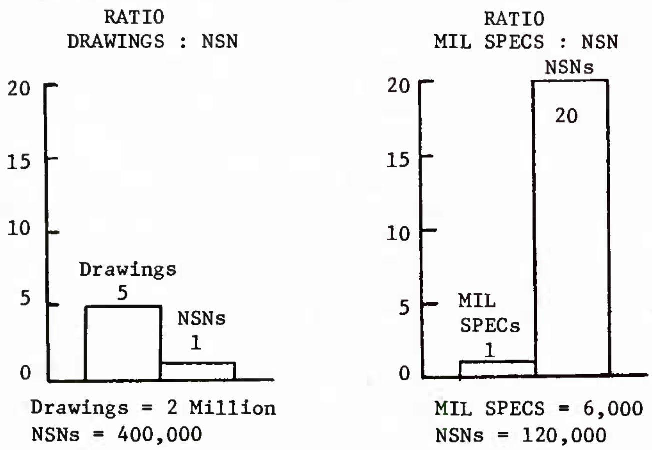


FIGURE 1: Commercial Drawings vs MIL SPECS for Electronic Parts Documentation

Because of the critical application of electronic parts, some form of documentation is better than none at all. The most difficult items to manage are those described to a part number only. According to the General Accounting Office (GAO), [13] inadequate documentation for items seriously hampers the item identification process and leads to the assignment of multiple stock numbers to identical items. The lack of adequate technical data at the time new items are cataloged largely explains the high number of items which are not assigned approved names or described characteristically.

Because of the cost of documentation, acquisition managers are often waiving the requirement, much to the dismay of the provisioner and the cataloger. As proponents for parts control, we feel we need to cut costs by the re-use of existing documentation, however, we also believe documentation should be acquired for those true nonstandard items placed into DoD supply bins.

A COMMON SENSE SOLUTION

Reducing the Paperwork A major benefit of the "MPCAG" concept is to cut down contractor goverment paperwork through the uniform application of standard part criterion and the encouragement of informal information exchange between the equipment designer and the MPCAG engineer. The informal exchanges of parts information eliminates paperwork and the submission of nonstandard part approval requests. Defense contractors using MPCAGs are provided names, telephone numbers and product assignments of all the MPCAG engineers. When telephone requests are received from the contractor, the MPCAG engineer immediately provides the most current parts information, and follows up by sending appropriate data to the contractor. This informal exchange of information saves time and money. MPCAG recommendations are given to both the contractor and the military procuring activity. The procuring activity evaluates the MPCAG recommended parts, and makes a decision based on system requirements. (We estimate that well over 90% of MPCAG recommendations become procuring activity decisions.) The contractor may appeal a MPCAG recommendation to the equipment procuring activity. (See figure 2.)

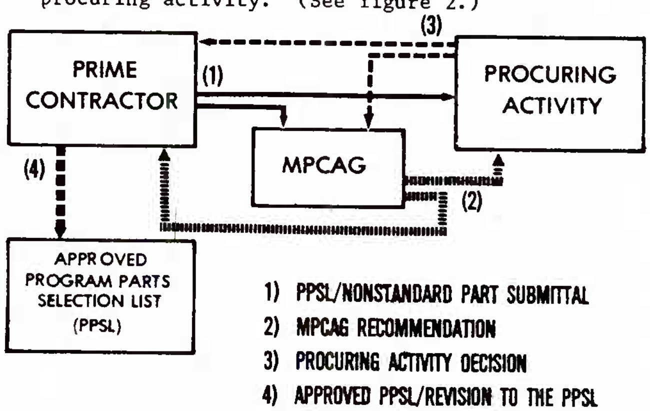


FIGURE 2: MPCAG, Procuring Activity, Contractor Interface

(NOTE: The informal exchange of information between contractors and MPCAGs is authorized by MIL-STD-965 and applies to all four DLA Hardware Centers, the Defense Construction Supply Center (DCSC), in Columbus, Ohio; the Defense Electronics Supply Center (DESC) in Dayton, Ohio; the Defense Industrial Supply Center (DISC) in Philadelphia, Pennsylvania; and the Defense General Supply Center (DGSC) in Richmond, Virginia.)

Parts Control Boards (PCBs) On major system acquisitions it has been shown that face to face meetings between the prime contractor, subcontractors and government parts experts can be very cost effective. For example, a representative from the Air Force Systems Command stated that "without parts control effort, the F-15 program would have required development of over 8,200 contractor detailed part drawings at a cost of $8 million. Since military specifications were available, this cost was avoided." [14] The F-15 program was the first major acquisition requiring the use of a formal Parts Control Board or PCB. While the F-15 used 35% more electronic parts than the F-4E, aggressive parts control action by the F-15 PCB reduced the different electronic part types used by 44%! (See figure 3.)

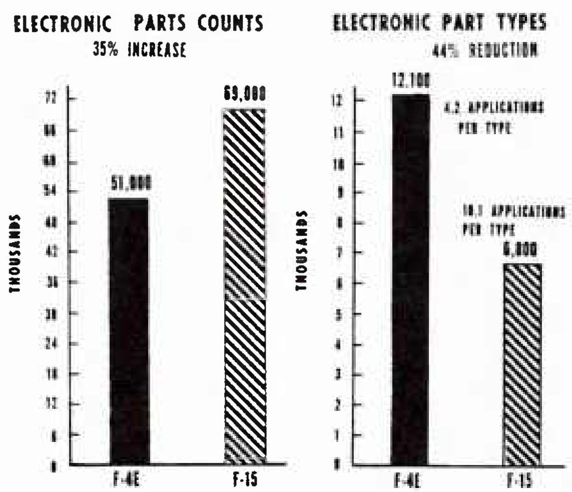


FIGURE 3: Parts Control Program Results

A modified PCB approach can be applied to "less than-system" acquisitions involving but one or two contractors in the design effort. The term "Parts Advisory Group" or PAG is often used when a "mini" PCB is considered appropriate.

Program Parts Selection Lists (PPSLs) MIL-STD-965 describes two procedures covering the submission, review and approval of PPSLs and changes thereto. Procedure I is usually applied on contracts not using Parts Control Boards (PCBs) while Procedure II is the method used for PCBs. The PPSL is used with either procedure. The intent of a PPSL is to obtain maximum re-use of documentation in design by tailoring and minimizing the variety of different types, grades or classification of parts to be applied in the acquisition. The PPSL is fluid and can be frequently adjusted during the various design phases as problems are resolved and technology progression dictates. One value of the PPSL lies in the opportunity for automation and the reduction of paperwork by handling bulk transactions rather than initially requiring the contractor to submit and justify each nonstandard part. The PPSL procedure discourages the premature preparation of parts documentation pending the determination that a standard part of equivalent quality is not already available. Requirements for test data are tailored to reflect realistic requirements commensurate with the program scope and phase. The acquisition manager is urged to use caution before requiring test data prior to establishing a firm application requirement for the item. A PPSL is not always appropriate for all design programs in which case only nonstandard parts are controlled. Through automation techniques developed over the past five years, the MPCAGs can prepare and maintain PPSLs as a service to the acquisition manager.

Parts Control and Solid State Technology In the age of solid state technology, it is no surprise that microcircuits (FSC 5962) and discrete semiconductor devices (FSC 5961) represent 35 percent of the nonstandard part types reviewed and evaluated by DESC/MPCAG. Solid state devices have a significant impact in the acquisition costs of DoD systems. In 1966, 21% of all parts used in DoD systems were solid state devices. The usage has now increased to 43% or more.

A significant problem in standardization is to issue specifications fast enough to meet contract schedule. DESC has reduced the preparation time by the use of word processing gear. Because of the technical complexity of characterizing all of the test parameters and conditions of an integrated circuit in accordance with MIL-M-38510, General Specification for Microcircuits, an interim procedure was developed to support the parts control program. The procedure permits DESC to prepare a selected item drawing (SID) to procure the item while data is being developed for the military specification. We are now seeing wide use of the DESC drawings for microcircuits. As in the case for MIL-M-38510 specificatons, the DESC drawings are closely monitored by the Rome Air Development Center (USAF), who is the sponsoring activity for MIL-M-38510. These documents are prepared at goverment expense and are "free" for use in acquisition and logistic support!

MIL-M-38510/101 - A Case Study Serious standardization efforts on microcircuits via MIL-M-38510 began with the F-15 Aircraft PCB in 1970. Since its development for the F-15 program, specification MIL-M-38510/101 has been applied in more than 125 programs, (Example, F-16, F-18, AWACS, XM-1, et.al.). The intra and inter-service standardization made possible by this document was a direct result of application recommendations made by MPCAG engineers. Of the 125 programs supported, 78 were Air Force, 29 Navy and 18 Army. In all, the MPCAG application of MIL-M-38510/101 has precluded the use of 491 nonstandard microcircuits since 1973. Based upon the cost avoidance criteria approved for the DoD Parts Control

System, the life cycle cost avoidance value of MIL-M-38510/101 has been computed to be $6.3 million. A good example of the advantages of standardization can be found in the MPCAG records of one standard part numbered M38510/10101BGC. This part, similar to the 741 operational amplifier, has replaced 17 different commercial item stock numbers in the supply system. Through consolidation, the annual cost to maintain stock for the "741" device was reduced to $165 for a single part number from $3,000 for the eighteen numbers. All the demand for the seventeen nonstandard parts was transferred to the M38510/10101BGC. Eventually, the procurement orders got large enough to reduce the cost of the military grade part to an all-time low. The average cost went from $10 to $2 per part. The lowest bid for this part in quantities of 20,000 was $1.77 per device with all bids close to the $2 mark. Prices drop from 55 percent to 78 percent when quantities increase from 100 to 20,000.

Much More To Do The objective of any engineering standardization effort is to make sure we do not impair the material readiness of equipment in the field by sacrificing quality and reliability requirements. As we have shown, it is possible to get a reliable standard device at a reasonable price. The demand for devices described to MIL-M-38510 requirements is caused by the high degree of confidence in the military specification system. DESC engineering invests $1.2 million each year in the standardization and product qualificaion of MIL-M-38510 products. Much more remains to be done as we approach the 80's.

Solid State Technology Standardization of the Future The Honorable William J. Perry, Under Secretary of Defense for Research and Engineering, has announced plans for a new initiative called the Very High Speed Integrated Circuits (VHSIC) Program. [15] The program is planned to extend over a six-year period at a cost of about $200 million. The technological objective should result in obtaining integrated circuits (ICs) in submicron sizes. The overall direction of the new program is to have useful and military specifications qualified VHSIC devices available for use in DoD programs a least five years ahead of present technology predictions. Engineers at DESC are pleased with the DoD emphasis on standardization and product qualification as a parallel goal of the VHSIC R&D process.

IMPACT OF STANDARDIZING DURING DESIGN

The lack of strong standardization effort during the design of new military systems and equipment can be equated to an increase in life cycle costs. Several cost drivers related to both acquisition and logistic considerations come to mind immediately. They are:

a. Engineering drawings covering nonstandard parts.

b. Verification testing of nonstandard parts.

c. Assignment and retention of National Stock Numbers NSNs for nonstandard parts.

d. Increased maintenance of equipment in the field.

Let us now examine each cost driver in more detail and describe how a parts control and standardization effort can avoid a large portion of the costs through the increased use of military standard parts.

Documentation Costs Original Equipment Manufacturer (OEM) drawings and specifications are required for documenting nonstandard parts used in new military equipment design. Obviously, parts that are fully described to military, Federal, or Industry Association standards avoid the need for the government to pay a contractor for the preparation of documentation for nonstandard parts.

A survey made by the National Aerospace Standards Committee (NASC) [16] cited many significant factors on the manhours required in industry to prepare piece part drawings. Survey responses showed a wide range of estimates of manhours per drawing when applied to specific product categories:

TABLE 1: Manhours to Prepare Drawings

Part Category	Manhours of work	Average Manhours
Passive Electronic Parts	2 to 145	34.8
Relays, Switches, Connectors and Similar Electromechanical	4 to 246	56.6
Diodes and Transistors	2 to 170	46.9
Integrated Circuits	24 to 220	71.7

According to the NASC survey, 67% of the drawings on the typical design program are new drawings. [17] To assess the benefits of parts control and to assure a conservative approach, we at DESC assume a drawing is prevented only 50% of the time when a nonstandard part type is replaced by a standard type through parts control.

The cost of a contractor prepared drawing for a nonstandard part type can range from $500 to $8000. [18]

The cost-benefit technique applied under the DoD Parts Control Program uses a conservative rate of $25 per hour to represent contractor engineering effort, G&A, overhead, and profit to prepare documentation. (A survey made by NASC in 1978 revealed $34 an hour will be used in their cost-benefit methodology.) Using $25 per hour, the estimated benefit from preventing the preparation of nonstandard part documentation is:

TABLE 2: Cost to Prepare Drawings

Product	Avg Hrs/ Drawing	Cost Avoided at $25/hr. (1970) Avg	Range
Resistors Capacitors Filters Coils	34.8	$870	$400-3625
Fuses, Ckt Breakers, Switches, Connectors, Relays, Waveguides, Wire, Cable	56.6	$1415	$450-6150
Eltr Tubes, Transistors, Diodes, Xtals	46.9	$1173	$400-4250
Integrate Circuits	71.7	$1793	$600-5500

Testing Costs Testing of nonstandard parts is a cost driver which can be avoided through parts control and the use of standard parts. The military services often require their contractors to test or have tested those nonstandard parts used in new design. Testing is also important to the contractor to assure that such parts will meet the performance requirements of the equipment.

In 1973, the American Institute of Aeronautics and Astronautics (AIAA) in a report [19] revealed that product testing is a very significant share of the funds for projects in development. As for piece parts, firms surveyed indicated that it was company policy and common practice to test all nonstandard electronic parts used in new equipment. An earlier survey by NASC indicated that testing is performed on 70% of nonstandard electronic items. [20] Parts manufacturers have informed DESC elec- tronics engineers that their investment in the testing of a new part can range anywhere from $5,000 to $25,000. (For example, the testing of a new integrated circuit device has been estimated as high as $100,000.) [21] So how does the use of standard parts avoid much of this testing cost?

Items described to military specifications are required to perform satisfactorily under military operating conditions, stress and environment. Normally, the cost of testing military standard parts is included in the price of the part since manufacturers voluntarily test their part for government approval and listing in Qualified Products Lists (QPLs). Since military specification parts are widely used, the cost of testing is relatively inexpensive when prorated to thousands of standard parts produced and sold by the manufacturer.

As in the case of nonstandard part drawings, the cost avoidance estimates for preventing testing costs are calculated from a conservative viewpoint. In our cost-benefit rationale we estimate testing costs are avoided on only 25% of the nonstandard parts replaced by standards. Based upon surveys and interviews, the cost avoidance from eliminating the need for testing of a nonstandard part in a specific part category is as follows:

TABLE 3 Cost to Test Parts

Product	Est Cost to Test
Resistors, Capacitors, Filters, Fuses, Ckt Brkrs Coils	$5,000
Connectors, Wire, Cable	5,500
Switches, Relays, Waveguides	6,000
Eltr Tubes, Transistors Diodes, Xtals	10,000
Integrated Circuits	25,000

Item Entry and Management Costs The cost driver associated with the assignment and retention of new NSNs to nonstandard parts for logistic support activity should be analyzed closely. Let us not forget that OEM and military drawings are the underlying cause of NSN proliferation through the entry of nonstandard parts into the DoD inventories. A new drawing covering a nonstandard part brings with it specific parts to eventually be entered and maintained in the logistics system to support military equipment in the field. The real proliferation occurs when the same or similar nonstandard parts are described in different contractor or service agency specifications or drawings and they too are assigned NSNs.

According to a report of the GAO, [22] the lack of centralized effort to control parts selection activity in new design leads to the cataloging of items unnecessarily in the government supply system. One of the basic objectives of parts control is to prevent the unecessary growth of nonstandard parts in DoD supply by offering design contractors standard parts already documented to Federal, military, industry and other related specifications and standards.

Drawings for nonstandard piece parts list an average of 7.3 different items per drawing according to a survey performed by the National Aerospace Standards Committee (NASC) in 1971 [23] Using 1965 data, the entry of each of these items into DoD supply bins could represent a 10 year operating cost of $165 per year per item. [24] The cost to enter an item in the inventory is $207. [25] Experience indicates that an approved nonstandard part type would add at least 3 new supply items when a new drawing is created.

If we apply these cost values to a single nonstandard part entering the DoD inventory and being retained in supply bins for 10 years we get:

Entry of one item (NSN assignment)	$207
Mgmt of NSN for 10 years	$1650
Total logistic cost of a single new nonstandard part	$1857

If we apply the criterion that the use of a standard part type prevents the development of a new document 50% of the time, then three new potential NSNs are also prevented. Thus, the logistics benefit from avoiding nonstandard part documentation is 50% X 3 X 1857 = $2,785.50. NOTE: A more recent study performed by the ARINC Research Corporation under contract for the Navy in 1978 reflected a cost for maintenance of an NSN to be $308 a year for 12 years, or $3696 for one item. [26]

Maintenance Costs The fourth cost driver we will examine is that associated with increased equipment maintenance actions due to poor reliability of nonstandard parts. The variety and quantity of different nonstandard electronic part types used in an electronic system can significantly increase field failures and drive upward life cycle support costs when failed devices must be located, removed, and replaced. The Electronics-X report [27] stated that in 1974 the annual maintenance costs for electronics in the DoD was $6.1 billion. Estimates of the cost of a field maintenance action ranged from $225 to $408 per action.

A research study on radar reliability demonstrated that emphasis on parts screening requirements of Established Reliability (ER), JANTX, and MIL-M-38510 military specifications would maximize performance and minimize costs. The report recommended that the use of lower graded devices be prohibited in electronic systems. Evidence provided indicated the use of high reliability electronic standard parts reduced maintenance actions by a factor of 3:1.

According to Dr. George Heilmeier, former Assistant Director, (Electronics and Physical Sciences), DDR&E [28] the DoD must pursue a continuing and comprehensive program to lower costs and improve the reliability of electronic equipment. Dr. Heilmeier expressed his concern that the government frequently buys inferior components to "in-house" part numbers, when Mil parts were available with average failure rates approaching .0045 percent/1000 hours. Dr. Heilmeier stated that each part failure in the field represented a maintenance action costing on the average over $300, and this did not include loss of equipment, life or mission effectiveness.

There is no easy method of showing cost relationships directly attributed to failures caused by not using high reliability standard electronic parts. The use of such parts can increase part costs from a small percentage (or even a slight decrease for some popular hi rel parts) up to three times the cost of commercial types. The extra cost at the part level could be worth it when you think of the following circumstances:

According to a Navy reliability authority, [31] the cost to find a defect at "module level is $110 and the next level $200. If you are going to find it at a system level the cost is $675. If you're going to find it at an installed level, it's $1100."

Such costs are staggering when you realize electronic price parts are relatively inexpensive items in comparison to the maintenance impact. (Have you had your T.V. set fixed recently?)

In developing our cost-benefit model for the DoD Parts Control System we wanted to include a factor showing the cost maintenance impact when nonstandard parts are designed into equipment. We chose to use $300 as a conservative benefit figure when using a high reliability standard electronic part type over a nonstandard.

A conservative estimate, based on past studies, permits us to assume that the prevention of one nonstandard electronic part type by the use of a standard type will avoid at least one maintenance action per year for 10 years.

Using $300 as the average cost per maintenance action, the maintenance cost avoided by using standard electronic part type is $3,000.

Program Results The parts control effort at DESC has had a payoff that is super in all aspects. Since 1972, DESC engineers have evaluated over 115,000 nonstandard part approval requests covering some 445,000 potential new items of supply. Because of DESC efforts, more than 50% of these items were found to be replaceable with preferred standard part types. Life cycle cost avoidances accrued from these early design decisions are estimated to be in excess of 600 million dollars. (See figure 4.)

Conclusion The old saying that "A chain is only as good as its weakest link" is still appropriate to the development of our weapons systems. Parts make up the system and all parts are required to meet the minimum requirements of a system. Practically all failures of defense systems can be attributed to failure of some part not meeting its design requirements. While benefits of the Parts Control Program cannot be easily analyzed, they are consistent with mass production philosophy and competitive spirit of industry. Examples of specific areas show that significant savings are being achieved. These benefits of parts control can be divided into three categories of program costs:

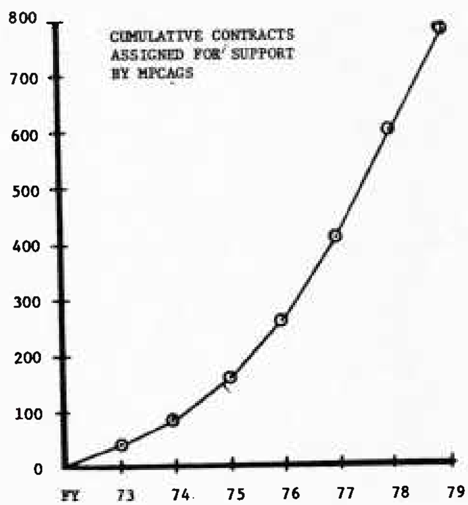
Acquisition Costs
Logistics Costs
Maintenance Costs

Acquisition Costs are reduced by eliminating the need for contractor drawings which identify similar parts or nonstandard parts which can be replaced by military standards. This also serves to eliminate the cost of verification testing of nonstandard parts and thus reducing the lead time to acquire parts from qualified suppliers.

Logistics Costs are reduced through less cataloging effort, less maintenance of National Stock Numbers, less salvage of inventoried items and less expensive but better quality replacement parts.

Maintenance Costs are reduced through lower failure rates and thus reduced maintenance actions. These costs are also reduced through consolidation of requirements providing for a reduction in part types needed for the design of individual equipments and systems.

We must avoid the pitfalls of costly engineering documentation, testing, logistics and maintenance associated with acquisition and deployment of military systems. We must recognize that "going commercial" is not necessarily the proper course when life cycle costs and field reliability are considered. We must be smarter in weapon system acquisition by using parts control and standardization during design. Remember: "The bitterness of poor quality is long remembered after the sweetness of low cost is forgotten!"



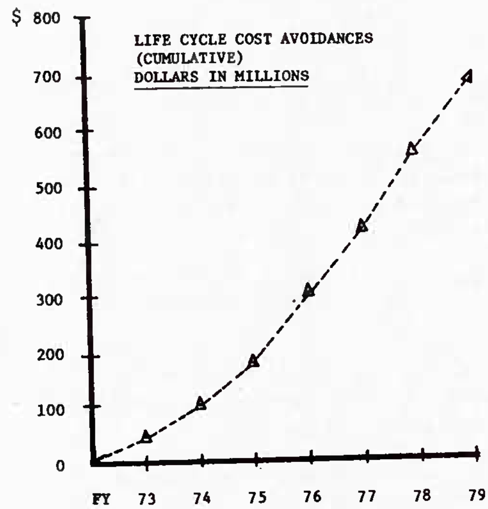


FIGURE 4: Growth of Parts Control Program

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AFFORDABLE AUTOMATIC TESTING - A MODULAR CONCEPT

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ABSTRACT

As the electronics in modern weapon systems has become more and more complex, the Air Force has reached a point where it can no longer field a major avionics system without fielding unique, complex and expensive automatic test equipment (ATE) to provide necessary support. This reliance has become so extensive that the Air Force is spending nearly 75% of its support equipment budget on developing and acquiring automatic test systems.

The Air Force recognized the need for aggressive action to reduce the cost of automatic weapon system support before it became entirely unaffordable. The Modular Automatic Test Equipment (MATE) Program was established to satisfy this need. The objective of the program is to decrease the life cycle cost of weapon system support by improving ATE management and acquisition practices, and reducing proliferation of weapon system unique ATE.

In June 1978, the MATE Program awarded contracts to Westinghouse Electric Corporation and Sperry Corporation to identify specific problem areas through an analysis of current Air Force policy and procedures in ATE acquisition and use, and develop a systematic approach tailored to overcome these problems. Both contractors have finished their surveys of DOD and industry, and are currently verifying the approaches they will recommend.

In this paper we will present some of the problems related to the development and acquisition of ATE, identify the life cycle cost drivers, and provide rationale on how a modular concept in ATE and a systems approach to acquisition result in affordable weapon system support. We will also discuss the Joint Logistics Commanders' Panel on Automatic Testing Study Plan and how the needs it identifies are being satisfied through the MATE Program and the efforts of the other services.

SUPPORT EQUIPMENT ACQUISITION

The Air Force provisioning process directs the acquisition of all items, including spare parts, required to support Air Force system, subsystems or equipment. The acquisition of support equipment is part of this process and includes the acquisition of all types of support equipment from common tool to complex test equipment.

The provision process as it relates to support equipment (automatic test equipment is a subset of support equipment) begins when the System Program Office (SPO) includes (in accordance with DAR) the requirements of AFSC/AFLCR 800-24 in the full scale engineering development contract for its system. This requires the contractor to identify all support equipment required to support the system being developed. The contractor identifies the functional support requirement and recommends a specific piece of equipment to meet the stated requirement. This information is transmitted to the SPO via a Support Equipment Recommendation Data (SERD) or more recently the E Sheet of the Logistics Support Analysis Record. The latter approach eliminates a data item when the Logistic Support Analysis is included in the development contract. These support equipment recommendations are, upon receipt, reviewed by all organizations who are or will be involved in acquisition, use, support, or management of the recommended support equipment item. Each of these organizations develops a position on each support equipment recommendation and forwards this position to the SPO. The SPO then makes a decision on each of the contractor's recommendations. The SPO has three basic options:

a. Approve the recommendation. When this is done, the recommendation may either be added to the system contract or the SPO may elect to acquire the support equipment from a different source. If the SPO decides to buy the support from the system contractor, the support equipment is added to the contract and the contractor develops, tests, and produces the equipment. When the SPO chooses to acquire support equipment from a different source, it incurs some advantages and some disadvantages. On the positive side, by showing that it has the capability to employ alternative sources, the SPO creates a competitive atmosphere in which support equipment can be acquired at a more reasonable price. On the negative side, the SPO accepts integration responsibility to insure the support

equipment performs its assigned function in support of the mission system. Assuming this responsibility may require technical resources beyond those normally available in a SPO, and the SPO Director must consider this when he decides to take this route. The approach of breaking out the support equipment is rarely taken due to the shortage of technical resources in the SPO.

b. Disapprove the recommendation. When this is done, the SPO is indicating that it does not plan to acquire any support equipment to meet the stated requirement. In essence, the SPO has determined that the requirement identified by the contractor is not valid.

c. Recommend a different alternative. In this case, the SPO is indicating there is a better item to perform the stated support function. In this case, the contractor evaluates the SPO's recommendation and provides the rationale for either accepting or rejecting the recommendation.

It should be noted that the Support Equipment recommendation is not the start of the whole process. There are a number of inputs which can and should be considered by the contractor in providing recommendations to the SPO. However, most of these inputs depend on actions taking place long before full scale engineering development begins. Accordingly, significant planning must be accomplished as early as the conceptual phase so that, when individual support equipment decisions must be made, a framework exists within which these decisions can be made in an intelligent and integrated fashion. Some key elements of this planning are as follows:

a. The system maintenance concept must be formulated as a part of the overall operational concept. This concept should address central issues such as the levels of maintenance to be used and the extent of automatic testing to be used opposed to manual testing. The decisions on these issues should be made based on detailed economic and technical analysis. Once the basic maintenance concept is developed, the SPO should continue to review and refine it as the program progresses and additional data becomes available.

b. A Logistics Support Analysis (LSA) should be performed as soon as the system configuration is sufficiently firm. This analysis is designed to examine every aspect of the weapon system and identify all of its support requirements.

c. A repair level analysis is often performed even when a complete logistics support analysis is not performed. This repair level analysis is used to determine the most economical allocation of support tasks across the different levels of maintenance. The results of this analysis are key to the ultimate determination of what support equipment is required at each level of maintenance.

d. A test requirements analysis should be required and the results documented in the test requirements documents (TRD) as outlined in MIL-STD-1519. These defined test requirements serve as the basis for the trade-off between automatic test equipment and manual test equipment. It also serves as a baseline document from which the basic design requirements for the automatic test equipment are extracted.

The support equipment acquisition process consists of a great deal more than simply acquiring individual items of equipment. Groundwork must be laid early in the program to provide a framework describing how all the system's support equipment will function as an integrated whole to do its job. Only when this groundwork is laid can the support equipment provisioning process function completely to identify and select the individual pieces of support equipment required to support the system.

PROBLEMS

The existing support equipment acquisition process was designed for the acquisition of all types of support equipment and, therefore, presents some inefficiencies in the acquisition of complex automatic test equipment. Automatic test equipment is vastly more complex than other categories of support equipment, and as a result, the existing provisioning process provides little of the needed visibility and controls to ensure effective management of automatic test equipment.

One of our major problems has been that the automatic test systems have not been mature when delivered to the Air Force. There are several reasons for this situation. First, as previously mentioned, the requirements for automatic test systems are not identified until well into the Full Scale Engineering Development Phase of the weapon system development. This circumstance, when combined with the long development time (48-60 months) of automatic test systems, usually leaves inadequate time before the operational need date for the proper development and test of the automatic test system. As a result, immature automatic test systems are deployed. Three major effects of this problem are:

a. The initial weapon system spares are rapidly depleted while the test programs are debugged. This causes many systems to operate at less than full capability.

b. The availability of the automatic test system is low due to a lack of verified self-test, calibration, and maintenance procedures.

c. Unprogrammed Interim Contractor Support is

required to supplement the automatic test system until it matures.

Another major problem with automatic testing has been that weapon system built-in-test features have generally not been effective. Also, a recent study in the Support Equipment SPO has shown that, when tested in the field, built-in-test features seldom meet specification requirements. Two common symptoms of deficient built-in-test are high false alarm rates and the large ambiguity groups to which the system isolates the fault. The high false alarm rate results in a lot of unnecessary maintenance and much higher than expected spares usage. The large ambiguity groups cause not only the bad unit, but also one or more good units, to be removed. Since the logistics planning for the system is based on the built-in-test meeting the specified values, the system is very difficult to maintain until the sparing levels are adjusted to compensate for the deficiencies in the built-in-test. In addition to rapidly using the available spares, both of these conditions result in a heavier workload on the intermediate and depot level test stations. This heavier workload, in turn, causes the test stations to be used more than expected and they eventually wear out before expected. This is the mode that several of our major weapon systems are now approaching. All of this is caused by a lack of early emphasis on built-in-test in the design of the units to be tested (design the unit then add built-in-test), a lack of standard ways of specifying built-in-test to allow accurate logistics planning, and a lack of tools and techniques to allow the progress on the built-in-test design to be measured at specific points in the design process.

Another significant problem arises from the fact that the support equipment acquisition process requires us to look at the test requirements of each weapon system independently. Each contractor recommends unique test systems designed to the testing requirements of the individual weapon system for which he is responsible. This leads to a proliferation of peculiar automatic test equipments, each of which is capable of supporting only one system or subsystem at one level of maintenance. One of the Modular Automatic Test Equipment (MATE) program contractors recently identified 434 different configurations of automatic test equipment in the Air Force inventory. The Air Force must bear the burden of supplying logistics support (spares, Technical Orders (T.O.s), training, etc.) for each of these unique configurations. What makes this problem so serious is the fact that many pieces of automatic test equipment are only used a small percentage of the time because their limited testing capabilities prevent cross-system utilization. In other words, we have purchased a great deal of capability which we are unable to use. In addition to the contractor's limited view of the Air Force maintenance environment, there are two other factors contributing to this proliferation of automatic test equipment. The first is that the Air Force does not have an effective data base that allows the efficient screening of existing automatic test equipment capabilities before developing new capabilities. Another reason for this proliferation is that the test requirements for each new system are slightly different. The design of existing test stations does not allow for changes to the test stations without an extensive modification program. For this reason, it is often more economic to develop a new automatic test station.

This proliferation of equipment has not been the only area of proliferation in the automatic testing arena. Until recently, each contractor had been free to use different programming languages. As a result of this proliferation of languages, our software support facilities have been forced to acquire and become proficient in the use of the programming tools associated with each of them. To illustrate the magnitude of this problem, a recent survey for the MATE program identified 42 major programming languages and 108 compilers, assemblers, and translators in use at our software support facilities. In addition to the large cost of acquiring these tools, the cost of training our personnel to use all these diverse languages and tools has been tremendous. The designation of IEEE ATLAS as the DOD standard test language has not completely solved this problem in that each company now has its own version of ATLAS.

A third significant area of proliferation in the automatic testing realm results from the fact that each contractor has used different, and in many cases, proprietary test programming aids for each system. Because of the high costs of buying the rights to these proprietary tools and of training our personnel in their use, this practice has made the maintenance and modification of test programs extremely expensive.

Another basic problem seen in the acquisition of automatic test equipment is that the test software is not effective when it is fielded. One reason for ineffective test software lies with the design of the unit to be tested. With today's complex electronics, the initial design of units to be tested must consider how the unit will be tested and must be designed to allow maintenance testing to be performed. Another reason for ineffective software is a basic lack of product assurance (and related tools and procedures) in the development of test programs. Studies by one of the MATE contractors have shown that a majority of the design errors made in developing test software are not detected until after the test software is fielded, thus making the errors extremely expensive to correct. Another contributing factor in ineffective test software is that until recently the test software impacts of changes to the unit to be tested were not considered or identified during the Engineering Change Proposal (ECP) process. Finally one of the most significant factors in the Air Force accepting ineffective software is a lack of standard qualification tools and techniques for the test software. Each SPO and contractor defines unique methods of accepting test software. These methods may or may not provide any indication as to the performance of the

test software. All of these factors lead to an expensive combination of long test times, high retest OK rates, high spares usage, and high test software costs.

AIR FORCE APPROACH

In order to address these problems associated with ATE, the Air Force established the MATE program in 1976 to develop and demonstrate a cost effective blend of state-of-the-art automatic test equipment technologies and management techniques to satisfy operational demands. The overall thrust of the MATE program is to reduce the life cycle cost of weapon system support. The objectives of the technical portion of this program are to establish criteria for multi-application equipment with modularity, flexibility, and growth provisions. The objectives of the management portion are to recommend improved procurement methods, management aids, management structures and policies/regulations. In order to accomplish these objectives, the MATE program has been divided into two major subprograms: MATE System and Programming Aids.

The purpose of the MATE System subprogram is to develop a systematic approach to the definition, acquisition, and support of automatic testing capabilities within the Air Force and is to investigate the feasibility of applying a modular concept to the development of automatic testing hardware and the associated software. The initial contracts for this subprogram were awarded to the Sperry Corporation and the Westinghouse Electric Corporation in June 1978. The end products of these contracts will be a series of four guides:

a. The Electronic Test Equipment Acquisition Guide will define the test equipment acquisition process and integrate it into the weapon system acquisition process.

b. The MATE Development Guide will define the process for developing a modular automatic test system.

c. The Avionics Testability Design Guide will define methods for designing easily tested avionics.

d. The MATE Production/Operational Guide will define the procedures required to use MATE test systems, to maintain configuration control of MATE test systems, data systems and equipment supported by MATE and to obtain feedback from Air Force operational organizations to keep MATE data systems current.

A fifth guide is currently being added to the MATE System. This guide, Test Program Set Acquisition Guide, will address how:

a. To improve the quality of ATE software used for testing of individual units. This type of software, when applied to a single unit, is referred to as a test program. In approaching this objective, we will first improve the quality of this software by developing a framework and all of the vehicle needed to adequately specify the performance requirements of the test software. We will then develop the necessary V&V tools and procedures for determining whether or not these performance requirements have been met.

b. To track and control the costs of ATE software, especially the test software. This objective will be accomplished through the development of a cost tracking mechanism for test program sets (hardware interface adapters as well as test software). Test program sets are the most expensive portion of any major ATE effort, since there are many (in some cases, hundreds) of them associated with each piece of automatic test equipment.

The thrust of the end products is to provide the Air Force with the capability to acquire automatic testing in a systematic manner. Beginning in 1981, these guides will be applied on a trial basis to a selected weapon system. If this demonstration is successful, MATE will be established by direction as the standard Air Force process for the identification, acquisition, and support of all automatic testing capabilities for all future weapon systems.

The objectives of the Programming Aids subprogram are to improve the automatic test generation capability to improve the quality and reduce the cost of test software and to establish the technology to simulator unit under test. The objectives of the automatic test generation portion of this subprogram are to:

a. Improve the performance of Digital Automatic Test Generation programs currently being used by our software support facilities by incorporating the desired features and by creating a qualified supplier list for use of Digital ATG on all future weapon systems.

b. Develop the capability to automatically generate test programs for analog and hybrid units (mixture of digital and analog circuits in the same unit). This capability does not currently exist. Development of it will greatly reduce the cost of analog and hybrid test programs and, since standardized test techniques will be used, will improve their quality.

These improved ATG tools will be available beginning in 1984 and will greatly improve the quality and reduce the cost of test software.

The objective of the unit under test (UUT) simulator program is to establish the technology required for development of improved test program evaluation, validation and verification methods. The subprogram will first investigate the economic and technical feasibility of simulating all functions of digital and analog UUTs. This concept will be employed to validate performance of test programs without the use of UUT hardware by simulating the

characteristics of faulty UUTs, thereby eliminating the problems associated with UUT nonavailability. This first portion will be managed by the Air Force Avionics Laboratory. After the feasibility has been demonstrated, the Support Equipment SPO will assume program management responsibility of this effort and will develop a guide for designing simulators for various types of UUTs.

The products of the MATE program will be a series of management tools necessary for implementation of a systematic approach to the acquisition of automatic testing capabilities, a series of software and test programming tools which will more efficiently test program generation and verification, and a series of specifications that define hardware and software modules from which test stations can be built. This program will serve as the basis for all future Air Force activities in the realm of automatic testing.

BENEFITS OF MODULAR AUTOMATIC TEST EQUIPMENT

A modular approach to automatic test equipment, as indicated by the title of this project, forms the cornerstone of the approach being investigated by the two MATE contractors. During the initial Survey/Study Phase the feasibility of this approach was investigated and found to be possible within the current state-of-the-art of automatic test equipment. This approach then became the basis for the architecture which drove subsequent decisions. Continued studies identified and quantified the problem areas and cost drivers previously described and determined feasible solutions.

Before the acquisition process could be controlled the critical aspects of the process had to be determined and the necessary visibility into these decision processes had to be provided. The result has been an Acquisition Guide identifying key decision points with all necessary management and technical tools provided for the program manager. This systematic approach has insured that all necessary pre-planning during the Conceptual Phase of the weapon system development is properly initiated. Therefore, at the time the support equipment acquisition process begins early in a full scale engineering development effort, all necessary inputs are available.

The Avionics Testability Guide has been designed to insure proper consideration during the Conceptual and Development phases of avionics development of those features that allow testing of the avionics UUTs to be carried out in a timely and efficient manner. By providing a technique for determining the proper amount of built-in-test necessary to satisfy the maintenance concept of the weapon system, built-in-test can be specified and incorporated into the design and the false alarm rates and large ambiguity groups previously characteristic of built-in-test can be minimized.

Fully utilizing the built-in-test characteristics of the avionics, and tracking any changes to these capabilities, a modular architecture of automatic test equipment can be imposed. The automatic test equipment developers have been provided better insight into currently available resources through the MATE data banks which contain listings of hardware, software, and human interface modules qualified to insure compatibility to the MATE architecture. The proper use of these data banks will minimize the proliferation of hardware. The hardware module interface standards have been developed to be compatible with current commercial standards. This has allowed an expanded use of commercial instrumentation with an associated decrease in development costs for unique designs. Standardized interface specifications and standardized instrumentation requirements also provide a means of overcoming the continuing problems of obsolescence. As modules go out of production and eventually become unsupportable due to spares shortages, new state-of-the-art replacements can be acquired and introduced into existing test stations with little or no change to station and test software.

With test program test accounting for 75 to 80% of automatic test equipment development costs, they have been given intense study by the MATE contractors and attacked from a number of directions to decrease their costs both in development and long term support. Preferred test procedures available in the Avionics Testability Guide will allow for more rapid generation of test requirement documents. A MATE subset of the IEEE ATLAS language is being developed to provide the full capabilities of this language without the redundancies and adaptations introduced over the past years. A fairly fixed subset will allow the training of programmers in one language and increase their proficiency to convert test requirements procedures into a computer processible form. The Software Design Guide provides them with a structure for test software. This structure is designed to increase understandability and traceability which are paramount during the maintenance of test software in future years. A standard set of programming aids is also being developed to meet all of the needs of the programmers. This will shorten the development time of test software since these tools can be provided directly to the automatic test equipment contractor and need not be redeveloped for each automatic test equipment acquisition program. The high costs of proprietary tools and continued training of personnel are also avoided.

The Test Program Set Acquisition Guide is being designed to insure that the automatic test equipment contractor and the Air Force clearly understand the life cycle of a test program set. How to specify the test program set requirements, the ability to properly document these requirements and a series of tools to measure the ability of a newly developed test program set to meet its specifications are being developed. This guide will insure that the Air Force accepts only comprehensive and complete test program sets capable of being fielded with a high degree of certainty that they are capable of performing their goal.

JOINT SERVICE EFFORTS

In July 1977, at the request of the Office of the Secretary of Defense, a coalition of industry associations comprised of the Aerospace Industries Association, the Shipbuilders Council of America, the Electronic Industries Association, the National Security Industrial Association, and the Western Electronic Manufacturers Association chartered the Industry/Joint Services Automatic Test Project. During its activities, this project addressed 17 areas which dealt with issues concerning the utilization of automatic test equipment and systems for cost effective support of weapon systems. These areas included: ATE operating and support software; automatic test generation; BIT and design for testability; nonelectronic test; microprocessors; advanced ATE technology; ATE interfaces; calibration; system engineering; education and training; ATE language standardization; test program sets; ATE acquisition; maintenance planning and concepts; resource management; and benefits analysis. In addressing these tasks, the project combined the inputs of over 800 people in the ATE community to develop recommendations for the improvement of automatic testing within DOD. The final report on this project will be published this summer.

When the Industry Associations agreed to initiate this project, it became apparent that the Services should prepare a plan for internal coordination of the management, acquisition support, and research and development of automatic testing among the Services. Accordingly, such a plan was prepared and presented to the Joint Logistic Commanders (JLC), a committee consisting of the commanders of the Department of the Army Readiness Command (DARCOM), the Naval Material Command (NMC), the Air Force Logistics Command (AFLC), and the Air Force Systems Command (AFSC). In March 1978, the JLC established a Panel on Automatic Testing and tasked it to coordinate and focus the automatic testing efforts of all the services. The panel is chartered to:

a. Develop methods for the reduction of the hardware, software, and manpower costs associated with automatic testing for support of weapon systems.

b. Devise policies, plans, and procedures for the most effective use of automatic testing hardware and software for improvement of the operational readiness of weapon systems.

c. Facilitate exchange among the Services and OSD of technical, managerial, and operational information on automatic testing hardware and software as applied to the support of weapon systems.

The panel has generated a six year study plan to guide the efforts of the services in improving the effectiveness of automatic testing throughout DOD. In order to generate this plan, the panel was divided into three subpanels: management, acquisition support, and testing technology. The plan identifies 82 subtasks which are grouped into 21 basic tasks. The management subpanel is responsible for five tasks which address policies and procedures, documentation, career guidance, organizational structure, and computer acquisition interfaces. The acquisition support subpanel is responsible for nine tasks which address terminology, information exchange systems, testability guidelines, logistics, test program sets, hardware interfaces, education and training, testing requirements, and automatic testing acquisition. The testing technology subpanel is responsible for eight tasks which address software, automatic test generation, design for testability, machinery testing, new technology, training and management aids, and advanced ATE concepts.

To implement each task, the members of each subpanel established a milestone schedule and estimated the manpower and funding required to complete each task. After these approaches to the tasks were approved by the panels, a lead command was selected to implement each task. Preliminary funding estimates indicate that implementation of the plan will require more than a quarter of a billion dollars through Fiscal Year 1983. More than 50 percent of the funding required for the JLC tasks are attributable to the MATE program.

An annual Joint Service Automatic Test Review is planned to provide inter-service communication concerning accomplishments and future plans. The overall study plan will be revised periodically to reflect the outcome of these annual reviews.

CONCLUSION

Through all of the aforementioned efforts, the Air Force is scrutinizing the current policies and procedures used to acquire and employ automatic testing capabilities and the associated systems. It has become more apparent that we can no longer afford to address the requirements of each weapon system separately; we must consolidate the management of automatic testing to assure more economical testing of our weapon systems. Within the Air Force, this will be accomplished through the MATE program and its interface with the Joint Services efforts.

TRANSPORTATION COSTS AS A CONSIDERATION IN AIR FORCE CONTRACTS

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ABSTRACT

The transportation decision is a financial decision coupled with the service constraints of the item(s) being transported. With this understanding, the scope of the research study was determined to include: identification of relevant transportation costs involved in government and/or contractor-sponsored carriage; development of a methodology for identifying and evaluating F.O.B. origin/destination alternatives; and to determine the feasibility of applying economic criteria to the transportation decision. Several conclusions were reached: (1) A significant number of Air Force contracts could be awarded F.O.B. origin; (2) The basic cost components which must be considered when comparing F.O.B. origin and F.O.B. destination terms of shipment include carrier rates, transportation administration expense, claims administration expense, contractor surcharge and destination change (ASI) costs; and (3) Significant dollar savings might be involved in utilizing F.O.B. origin terms of shipment. A methodology was proposed for evaluating the F.O.B. terms of shipment decision.

INTRODUCTION

Scope of the Problem. Transportation costs account for a substantial portion of the distribution budget of any organization. It is imperative therefore, that these costs be understood and controlled. Like many business organizations, the United States Air Force faces problems of mode and carrier selection, routing and scheduling, rate determination, and many others. For an organization such as the U.S. Air Force, these problems are compounded by the multiplicity of commodities, shipping/receiving locations, sensitivity of the item, priority of need, etc.

Many transportation decisions are made by the shipper (contractor) under F.O.B. destination contracts versus those the U.S. Air Force (purchaser) makes under F.O.B. origin terms of a contract. For those shipments made by the contracting firm, additional costs of the contractor's overhead/burden, administrative costs, and profits are added on to the transportation costs. A method is needed by the U.S. Air Force to assess the economic impact of these fringe costs tacked on to the transportation costs, prior to the award of procurements, so that a determination can be made as to whether the Government could provide the transportation of the item(s) at a lower cost than that proposed by the bidder. In actuality, the decision becomes one of whether or not the U.S. Air Force should accept the F.O.B. origin bid on the one hand or the F.O.B. destination (delivered) bid on the other. It was the basic question that this study attempted to answer.

Background. As stated in the USAF First Destination Transportation (FDT) Study, 6 October 1977, conducted by the logistics and accounting staff of Air Force Systems Command and Logistics Command:

> When the F.O.B. destination method of transportation is selected by the PCO, Defense Acquisition Regulation (DAR) 7-104.71 clause is included in the contract. Under this type of contract, the contractor is responsible for the transportation costs and passes these costs on as a part of the purchase price of the item. Total contract costs are paid from program funds and transportation costs are not separately identified. Although the government ultimately pays for the transportation, FDT expenditures are not involved as a specific cost. Therefore, FDT charges cannot be extrapolated and the annual magnitude cannot be stated or estimated.

It was the uncertainty surrounding the costing aspects of the F.O.B. destination decision that prompted Air Force Logistics Command (AFLC) to request that the Air Force Business Research Management Center (AFBRMC) investigate transportation costs as a consideration in government contracts. It was recognized by AFLC and AFBRMC that the intent of DAR 19-100 could not be fully complied with, without further information. DAR 19-100 states that "Transportation and traffic management factors are important in awarding and administering contracts to assure that procurements are made on the basis most advantageous to the government, all factors considered, and that supplies arrive on time, at the required place, in good condition." Obviously, "all factors

considered" must incorporate a thorough knowledge of the cost implications that the F.O.B. terms-of-sale have on the government.

Scope of the Study. Basically, the transportation decision is a financial decision coupled with the service constraints (priority and sensitivity) of the item(s) being transported. Service was not incorporated within the research study because it may override the financial considerations of the transportation decision. For example, a high priority item or one of Top Secret classification may be shipped by LOGAIR or commercial air freight, regardless of the cost, because of the nature of the shipment. Consideration of the service element can never be ignored in the transportation decision, but this research will assume that service constraints are such that they will not affect the transportation decision; i.e., service will be held constant.

The research study on which this paper is based was a basic fact-finding mission which was to result in the identification of relevant transportation costs involved in government-sponsored and contractor-sponsored carriage. In that regard, the study has been successful. Identification of those costs was necessary in order to made the F.O.B. origin/destination decision.

Other purposes of the research were to develop a methodology for identifying and evaluating F.O.B. origin versus F.O.B. destination alternatives, and to determine the feasibility of applying economic criteria to the transportation decision.

Major Assumptions Made in the Research Study. Whenever "new" ground is broken in research, the researcher must make a number of assumptions. Those assumptions should be consistent, logical, and operationally sound. They must also be realistic and should not compromise the conclusions and recommendations formulated by the researcher. In this research study, the major assumptions made included:

1) The Air Force has full authority to direct contractors to bid F.O.B. origin and/or F.O.B. destination on all contracts not expressly prohibited under existing regulations and directives.

2) Because of a lack of reporting formulae for contracts under $100,000, it is assumed that a contractor's percentage surcharge (profit or fee) would be the same, regardless of the size of the contract.

3) The surcharge (profit or fee) added by a contractor to the overall contract would be equally applied over every component of that contract (based on the belief that each component must contribute proportionately to the contractor's Return on Investment (ROI) requirements or internal "hurdle rate").

4) Transportation administration costs are assumed to remain constant regardless of the size of the shipment.

5) F.O.B. origin shipments involve additional claims administration expense over that incurred on F.O.B. destination shipments.

6) In contracts extending over long periods of time, destination changes may occur. The resulting Amended Shipping Instructions (ASI's) involve additional costs to the government. The computations made in this study do not include the cost for ASI's on F.O.B. destination contracts, but it should be realized that these costs are FDT costs and must be considered.

Research Questions. Basically, the U.S. Air Force is faced with a multi-faceted decision which includes the following:

1) What cost elements should the Air Force consider when making the decision to select either F.O.B. origin or F.O.B. destination?

2) When should the Air Force solicit both F.O.B. origin and/or F.O.B. destination bids?

3) When should the Air Force assume the transportation administration function required under F.O.B. origin terms?

4) What factors, in addition to transportation costs, should the Air Force consider when making the choice between F.O.B. origin and F.O.B. destination bids?

METHODOLOGY

Two data collection procedures were employed in this research study--personal interviews and review of secondary information sources. The personal interviews involved four basic groups involved in the F.O.B. origin/destination decision: (1) AFLC; (2) Air Logistics Centers (ALC's)(Ogden, Warner Robins); (3) Air Force Plant Representative Offices (AFPRO's) and/or Defense Contract Administration Services (DCAS's); and (4) private contractors or industry representatives. Primary military contacts included personnel involved in the contracting and administration function and personnel in the transportation area. Individuals contacted in private industry included persons in the traffic and transportation areas as well as those involved in general logistics or physical distribution activities. The personal interviews provided much of the data used in this research study that was not or could not be readily obtained from existing government data sources.

Secondary information sources cited included previous government studies of the transportation or contracting/acquisition functions. Basically, they familiarized the researcher with current Air Force policies and procedures. A large number of past Air Force contracts were

reviewed in order to develop the cost components of the F.O.B. origin/destination decision. As part of the contract review process 268 DD Form 1499's were audited (FY 1978) to determine the contractor surcharge (profit or fee) added onto a typical Air Force contract. Audits of several Transportation Automated Rate System (TARS) reports were performed to determine the rate differential that existed between Interstate Commerce Act Section 22 Rates and regular commercial carrier rates.

Miscellaneous non-government information sources were also reviewed to obtain cost figures for certain components of the F.O.B. origin/destination decision including transportation administration expenses, claims administration expenses, and other relevant costing data.

FINDINGS

Air Force Transportation Regulations. The primary Air Force regulation governing the administration of the transportation activity in contract procurement is DAR 19. As presently written, the DAR identifies the circumstances which govern F.O.B. origin versus F.O.B. destination terms. A review of the DAR shows no major difficulties inherent in the procedures specified for selecting between F.O.B. origin and F.O.B. destination. There are, however, several minor deficiencies in the DAR which make it difficult for the Transportation Officer and Contractor Officer to monitor, control and administer the F.O.B. term decision as effectively as possible. As presently written, F.O.B. destination transportation charges for contractual shipments are incorporated within the negotiated unit price or total price of the contract. Precise identification of those costs are presently impossible under existing DAR regulations.

Four modifications in DAR 19 were recommended: DAR 19-904.2(b); (d)(1)(vi); DAR 19-208.1(a); and DAR-208.4(c). The changes specified aim at providing a sound base for making optimal transportation costing decisions with respect to the F.O.B. terms of shipment. In addition, the changes recommended would facilitate the future monitoring and collection of data necessary in making the most cost effective F.O.B. terms decision.

F.O.B. Origin Versus F.O.B. Destination. Using 1976 data, the annual FDT expenditures for F.O.B. origin totalled \$20.7 million for Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC). Total expenditures (budgeted) for all Air Force Research Development Test and Evaluation (RDT&E) and contract funding was \$11.4 billion. While the percentage of F.O.B. origin shipments is small, the dollar amount is significant.

In analyzing the F.O.B. terms of shipment decision, the various cost components of F.O.B. origin and F.O.B. destination had to be identified. Specifically, those components had to be isolated which would change as the F.O.B. terms of shipment changed. The components which did not vary with the terms of shipment; e.g., insurance, loss and/or damage; were not evaluated in this research study. The cost components identified which varied between F.O.B. origin versus F.O.B. destination, and therefore important in the terms of shipment decision, were as follows:

F.O.B. Origin	F.O.B. Destination
Section 22 rates	Regular commercial carrier rates
Transportation administration expense	Contractor surcharge (profit or fee)
Added Claims administration expense	Transportation administration expense
	Destination change (ASI) costs

Basically, the research study involved the specific identification or estimation of those costs and a subsequent comparison of the total costs involved in F.O.B. origin versus F.O.B. destination shipments. With other factors such as service and sensitivity being held constant, the optimal decision for the Air Force would be selecting the alternative of least cost.

Transportation Costs. The first component of the terms of shipment decision, and the largest, was the transportation rate. As identified in the DAR, the government can ship its products under Interstate Commerce Act Section 22 rates which are considerably lower than regular commercial carrier rates. Without Section 22 rates, most government shipments would have to be moved at class rates which are higher in cost and which require extensive material classification, thus, consuming considerable amounts of time and greater government expenditures for transportation.

In this research study, it was assumed that the great majority of F.O.B. destination shipments were not being shipped under Section 22 rates, while F.O.B. origin shipments used, almost exclusively, the lower Section 22 rates. There was some uncertainty as to whether this assumption was completely valid; and, as it turned out, the final terms of shipment decision was not determined by the presence or absence of Section 22 rates.

As shown in Table 1, the Section 22 rates are substantially lower than regular commercial motor carrier rates. While Section 22 rates can apply to other modes in addition to motor, the majority of Air Force shipments are sent via motor carriage, and it was believed that similar findings would be generated if other modal rates were used.

Available TARS reports were used to identify the Section 22 rates in effect. The motor carrier rates for Class 100 commodities were

selected for comparison. Rates between the five ALC's and WPAFB were developed, and average rates were calculated. The Section 22 rates and commercial motor carrier rates differed by 17.6 percent to 25.6 percent. In every instance, Section 22 rates were lower (or identical when very small shiments were involved).

Table 1. Comparison of Section 22 and Commercial Motor Carrier Rates Freight All Kinds (FAK)
Average of all ALC's* to WPAFB

Weight (LBS.)	Commercial Rate (per cwt)	Section 22 Rate (per cwt)
1	18.65	15.25
500	16.93	12.59
1000	15.25	11.90
2000	13.34	10.61
5000	11.32	9.32
10000	10.62	8.74
Volume	10.83	8.67

*Included Sacramento ALC, Warner Robins ALC, Oklahoma City ALC, Ogden ALC, and San Antonio ALC.

Transportation Administration Costs. The second component of the F.O.B. terms of shipment decision was transportation administration expense. If the Air Force were to assume the transportation administration function required with F.O.B. origin shipments, additional costs would be incurred. The only government data available on transportation administration costs is presented in Table 2. The $50 cost was not used in the F.O.B. terms of shipment comparison. The amount was considerably higher than the other cost figures that were developed. Further, no evidence could be located concerning the validity of the $50 figure. In Table 2, the costs used to determine an average transportation administration cost are presented. The majority of the figures shown were developed from interviews with distribution and transportation executives in private industry. The smallest of the figures for freight bill costs were developed from companies where automated systems were being used to develop, process, and administer the transportation activities of the companies. Where manual systems were being used, the costs were somewhat higher. If the Air Force assumed the administration function, their costs would vary between the extreme points with eventual reductions in costs as the process become computerized.

Table 2. Administrative Costs for Transportation Activity

Source	Cost per Freight Bill* Military	Commercial
OO-ALC/DS Msg	$50.00	
GSA	15.58	$ 7.68
Appliance Mftg.		2.39
Food Mftg.		16.50
Pharmaceutical Mftg.		2.14
American Trucking Assoc.		5.80 (est.)

*Includes labor, EDP, communications and other miscellaneous costs.

RANGE = $2.14 to $16.50 MEAN = $9.67

Claims Administration Costs. The final component relevant to F.O.B. origin shiments was claims administration expense. There are costs involved in processing and administering claims under F.O.B. origin and F.O.B. destination shipments. The degree of Air Force involvement in the handling of the claim is limited, however, when loss and/or damage occurs under an F.O.B. destination shipment. Under F.O.B. destination shipments, the carrier and the contractor would administer and process the claim. Under F.O.B. origin shipments, the Air Force would assume the contractor's responsibility and work with the carrier to handle the claim. In each instance, additional costs would be incurred by the Air Force. From a variety of industry sources, a one (1) percent of motor carrier cost figure was developed. The sensitivity of the 1 percent figure was tested in the final F.O.B. origin versus F.O.B. destination decision and it was found that the decision would not be affected even with significant variations (±100%) in the claims administration percentage.

Contractor Surcharge. A significant cost component of F.O.B. destination shipments is contractor surcharge (profit or fee). The exact percentage employed by contractors on F.O.B. destination contracts was somewhat elusive. For contracts under $100,000 no data were available. For contracts over $100,000 the DD Form 633, and for contracts over $500,000 the DD Form 1499 were used to develop the contractor surcharge (profit of fee). It was assumed that contractors would add the same surcharge to contracts under $100,000. The interviews with two government contractors tended to support this assumption. The logic for this assumption was based on the fact that the Return On Investment (ROI) requirements would not vary by contract size, and therefore, the contractor would require a certain ROI on all contracts--commercial or military. In addition, while there are many more contracts under $100,000 than over $100,000, the total dollar value of contracts over $100,000 is much greater. This result is an example of the 20/80 rule in inventory management (20 percent of your products account for 80 percent of your volume or sales).

The information provided on the DD Form 633 and DD Form 1499 is essentially the same except for the fact that DD Form 1499 reports the final negotiated contractor surcharge (profit or fee) which may be different than the initial contractor bid or government stated objective. The surcharge that is important is the final figure arrived at after negotiation, not before, because it represents what the government must pay the contractor. Another difference between the DD Form 1499 and DD Form 633 is that the former is completed only on contracts larger than $500,000. The DD Form 1499 was selected for audit in this research study because of its availability at AFLC. As per DAR 21-304, each ALC must submit the DD Form 1499 to AFLC. It was, therefore, possible to examine F.O.B. destination contracts from all five ALC's rather than one or a few. DD Form 633 is not submitted to AFLC and remains with the contract file. Also, the final negotiated surcharge is not identified on the DD Form 633.

An audit of 268 DD Form 1499's was made at WPAFB. The audit included forms submitted from FY 1978. The range of surcharges was .999 percent to 15.1458 percent. The average contractor surcharge was 8.56 percent. The minimum, maximum, and average figures were subsequently used in the determination of optimal F.O.B. terms of shipment decision.

As identified on the DD Form 633 and DD Form 1499, the contractor includes as part of his bid "general and administrative expenses" and "other expenses." Although not specifically identified, the contractor's transportation administration activities would most probably be included in one or the other of the two cost categories just mentioned. In this research study the transportation administration expense of the contractor was assumed to equal that of the government and the cost figures from Table 2 were used. In Table 3 the surcharge was applied to the motor carrier cost and the transportation administrative cost.

Destination Change Costs. The final component of F.O.B. destination shipments was the cost involved in making destination changes (ASI's). This is an important First Destination Transportation (FDT) cost which is not explicitly considered in many F.O.B. terms of shipment evaluations. It can, however, be a significant cost factor with some shipments. Information obtained from the San Antonio ALC showed that for each ASI some contractors have charged as much as $150 and as little as $6. Some contractors do not charge for ASI's. It is apparent that for small dollar contracts this charge could completely alter the F.O.B. terms of shipment decision. In this research study it was not possible to identify the number of ASI's processed on F.O.B. destination contracts, nor the number of contracts involving ASI's. Therefore, the costs for processing ASI's were not incorporated in the final F.O.B. terms of shipment computations. It should be remembered, however, that the cost for ASI's should be considered in the F.O.B. terms of shipment decision. These costs are especially important in small dollar contracts.

Economic Comparison of F.O.B. Origin Versus F.O.B. Destination: After having identified and determined the cost components of the F.O.B. terms of shipment decision, it was necessary to make a direct comparison between F.O.B. origin and F.O.B. destination. Table 3 shows the results of those comparisons. In Table 3, Section 22 rates were used in comparing F.O.B. terms of shipment. When Section 22 rates were not used, the finds remained unchanged. The rationale for the two comparisons was based on the possibility that Section 22 rates may be eliminated within the near future as deregulation of the transportation industry occurs.

A variety of comparisons were made based on shipment size (in pounds). Three possible environments were hypothesized: (1) most optimistic; (2) most pessimistic; and (3) most probable. In the most optimistic environment, the lowest cost figures for transportation administration costs, claims administration costs and contractor surcharge (profit or fees) were used. In the most pessimistic enviroment, the highest figures for each cost component were used. And, in the most probable environment, the averages of each component were used. It was felt that utilizing the minimum, maximum, and average costs for each component would provide comparative statistics for all possibilities. This rationale was employed with and without Section 22 rates in effect (the paper shows results of only Section 22 rates).

An economic comparison of F.O.B. origin versus F.O.B. destination with Section 22 rates in effect revealed that in each of the three environments, F.O.B. origin terms were most beneficial to the government, regardless of shipment size. Without Section 22 rates in effect, F.O.B. origin terms were most beneficial to the government, regardless of the size of the shipment. Specific exceptions would include those shipments that would normally be sent via Parcel Post or United Parcel Service. Generally, as the size of the shipment is increased, F.O.B. origin terms resulted in larger dollar savings to the government.

Table 3. Overall Economic Comparison of F.O.B. Origin/Destination Shipments (With Section 22 Rates in Effect)

Weight of Shipment (lbs)	Motor Carrier Cost(1)	Transportation Administrative Costs(2)	Claims Administrative Costs(3)	Surcharge(4)	Total
Most Optimistic					
F.O.B. ORIGIN					
1	15.25	2.14	.15	-	17.54
500	62.95	2.14	.63	-	65.72
1000	119.00	2.14	1.19	-	122.33
2000	212.20	2.14	2.12	-	216.46
5000	466.00	2.14	4.66	-	472.80
10000	874.00	2.14	8.74	-	884.88
Volume (15000)	1300.50	2.14	13.01	-	1315.65
F.O.B. DESTINATION					
1	18.65	2.14	-	.21	21.00
500	84.65	2.14	-	.87	87.66
1000	152.50	2.14	-	1.55	156.19
2000	266.80	2.14	-	2.69	271.63
5000	566.00	2.14	-	5.68	573.82
10000	1062.00	2.14	-	10.64	1074.78
Volume (15000)	1624.50	2.14	-	16.27	1624.91
Most Pessimistic					
F.O.B. ORIGIN					
1	15.25	16.50	.15	-	31.90
500	62.95	16.50	.63	-	80.08
1000	119.00	16.50	1.19	-	136.69
2000	212.20	16.50	2.12	-	230.82
5000	466.00	16.50	4.66	-	487.16
10000	874.00	16.50	8.74	-	899.24
Volume (15000)	1300.50	16.50	13.01	-	1330.01
F.O.B. DESTINATION					
1	18.65	16.50	-	5.33	40.48
500	84.65	16.50	-	15.32	116.47
1000	152.50	16.50	-	25.60	194.60
2000	266.80	16.50	-	42.91	326.21
5000	566.00	16.50	-	88.24	670.74
10000	1062.00	16.50	-	163.39	1241.89
Volume (15000)	1624.50	16.50	-	248.61	1889.61
Most Probable					
F.O.B. ORIGIN					
1	15.25	9.67	.15	-	25.07
500	62.95	9.67	.63	-	73.25
1000	119.00	9.67	1.19	-	129.86
2000	212.20	9.67	2.12	-	223.99
5000	466.00	9.67	4.66	-	480.33
10000	874.00	9.67	8.74	-	892.41
Volume (15000)	1300.50	9.67	13.01	-	1323.18
F.O.B.DESTINATION					
1	18.65	9.67	-	2.42	30.74
500	84.65	9.67	-	8.07	102.39
1000	152.50	9.67	-	13.88	176.05
2000	266.80	9.67	-	23.66	300.13
5000	566.00	9.67	-	49.27	624.94
10000	1062.00	9.67	-	91.73	1163.40
Volume (15000)	1624.50	9.67	-	139.88	1774.05

Footnotes for Table 3

1. F.O.B. origin shipments: The section 22 rates were used. F.O.B. destination shipments: The regular commercial motor carrier rates were used.

2. F.O.B. origin shipments: Most Optimistic used the lowest administrative cost, for the Most Pessimistic the highest administrative cost, for the Most probable the average of all administrative cost from Table 2 was used. F.O.B. destination: Administrative costs would be assumed by the contractor.

3. F.O.B. ORIGIN: Composite percentage of 1 percent of motor carrier cost was developed from a variety of industry sources and would include the additional costs involved in handling and processing F.O.B. origin shipments.
F.O.B. DESTINATION: Claims administrative costs could be assumed by the contractor.

4. F.O.B. ORIGIN: Contractor surcharge does not apply to F.O.B. origin shipments.
F.O.B. DESTINATION: Most Optimistic lowest surcharge from the paper. Most Pessimistic highest surcharge for the paper. Most Probable the average of all surcharges.

In order to determine the magnitude of potential cost savings to the Air Force if contracts for FY 1977 had been F.O.B. origin in lieu of F.O.B. destination (whenever possible), the Ogden ALC was selected for evaluation (similar results would occur if other ALC's were selected). Because no data were available concerning the percentage of F.O.B. destination contracts which could have been F.O.B. origin, various environments were used. At the Ogden ALC, 21,931 actions involving $716,000,000 were transacted in FY 1977. Based on a total of 21,931 actions (shipments), Table 4 was developed to show the magnitude of potential cost savings to the Air Force if F.O.B. origin terms had been used in lieu of F.O.B. destination terms. The reader is cautioned to regard the savings identified in Table 4 as approximations only. As it will be proposed later in the paper, specific data must be collected from actual contracts in order to develop exact cost savings. The savings identified in Table 4 do, however, indicate the substantial dollar amounts that might be realized from the F.O.B. terms of shipment decision.

In Table 4, the average cost differential for each environment (Most Pessimistic, Most Optimistic, and Most Probable) was used to calculate the potential cost savings. In every instance, the total cost figures (last column in Table 3) were compared for each shipment weight category. For each weight class, the F.O.B. origin total was subtracted from the F.O.B. destination total; e.g., in the 1-100 pound category in the Most Optimistic environment, $17.54 was subtracted from $21.00. This was done for each weight class and the results were summed and an average was determined. The use of an average assumes a normally distributed populatin of shipment sizes. This was considered a reasonable assumption inasmuch as no data were available and any resulting bias would be towards larger shipments. In that case, the average cost differential figures would be understated and the resultant savings would be larger. Then, for varying amounts of F.O.B. origin shipments (100 percent to 5 percent) the potential cost savings for the Ogden ALC were calculated. Depending on the number of shipments that were F.O.B. origin, the savings ranged from a low of $114,801 to a high of $4,023,023. Realistically, the cost savings would probably be closer to the lower figure since a number of shipments would have to be sent F.O.B. destination as per DAR regulations.

CONCLUSIONS

The Air Force must determine whether or not it should accept the F.O.B. origin bid on the one hand or the F.O.B. destination (delivered) bid on the other. This research study addressed that basic question. As a result, the following conclusions have been developed:

1. A significant number of contracts could be awarded F.O.B. origin in lieu of F.O.B. destination.

2. Explicit F.O.B. terms of shipment data do not presently exist in the Air Force under present operating systems.

3. The basic cost components which must be considered when comparing F.O.B. origin and F.O.B. destination terms of shipment include carrier rates (Section 22 versus regular commercial), transportation administration expense, claims administration expense, contractor surcharge (profit or fee), and destination change (ASI) costs.

4. An important component of FDT costs--ASI's--is presently not being adequately considered in the F.O.B. terms of shipment decision. Particularly for small dollar shipments, costs for ASI's can be a significant portion of total transportation costs.

5. When Section 22 rates apply, F.O.B. origin terms of shipment were most beneficial to the government whatever the size of the shipment.

6. If Section 22 rates did not apply (or if they were eliminated under future deregulatin of the transportation industry), F.O.B. origin terms of shipment were most beneficial to the government whatever the size of the shipment.

7. Although more specific data are needed, it was found that significant dollar savings might be involved in utilizing F.O.B. origin terms of shipment in lieu of F.O.B. destination terms.

Table 4. Estimated Cost Savings to Air Force if Contracts at Ogden ALC (FY 1977) Had Been F.O.B. Origin (With Section 22 Rates in Effect)

Most Optimistic

Percent of Shipments F.O.B. Origin	Number of Shipments (X)	Average Cost Differential (=)	Savings
100	21,931	104.65	$2,295,079
75	16,448	104.65	1,721,283
50	10,724	104.65	1,122,267
25	5,483	104.65	573,796
10	2,193	104.65	229,497
5	1,097	104.65	114,801

Most Pessimistic

Percent of Shipments F.O.B. Origin	Number of Shipments (X)	Average Cost Differential (=)	Savings
100	21,931	183.44	$4,023,023
75	16,448	183.44	3,017,221
50	10,724	183.44	1,967,211
25	5,483	183.44	1,005,802
10	2,193	183.44	402,284
5	1,097	183.44	201,234

Most Probable

Percent of Shipments F.O.B. Origin	Number of Shipments (X)	Average Cost Differential (=)	Savings
100	21,931	146.23	$3,206,970
75	16,448	146.23	2,405,191
50	10,724	146.23	1,568,171
25	5,483	146.23	801,779
10	2,193	146.23	320,682
5	1,097	146.23	160,414

RECOMMENDATIONS

Specific recommendations resulting from the research study and following from the conclusions previously mentioned include:

1. Consider the possible revision of the DAR as previously suggested.

2. Solicit F.O.B. origin and F.O.B. destination bids on all contracts which may be shipped via origin or destination terms of shipment.

3. Until more specific information becomes available, award contracts on F.O.B. origin terms whenever possible. Specific exceptions would include those shipments that would normally be sent via Parcel Post or United Parcel Service.

4. At a selected ALC, institute a pilot program where F.O.B. origin versus F.O.B. destination cost differentials can be compared. Such a program could encompass all contracts which could be shipped F.O.B. origin in lieu of F.O.B. destination over an adequate time period.

One consideration which should be examined by the Air Force if more contracts were awarded F.O.B. origin would be that portion of contractor overhead attributable to transportation. While the contractor surcharge for transportation would be eliminated, the transportation overhead most probably would not. In those instances where the contractor has a traffic department or traffic personnel, the costs for their activities become part of the contractor's overhead. In most cases, however, the contractor probably could not specifically identify overhead costs resulting from transportation because of data availability problems. Also, the percentage of overhead due to transportation would be small when compared to manufacturing, engineering, and other components.

Therefore, even if the Air Force were to solicit bids on an F.O.B. origin basis, they would be incurring some additional, and at present, unidentifiable, transportation costs.

An additional recommendation, not directly related to the purposes of this research study, refers to DAR 19-403.2. During the personal interviews it was indicated by some government personnel that the use of prepaid commercial bills of lading may be economically inefficient in some cases. It appears that multiple shipments under a single contract or several contracts awarded to the same contractor could be consolidated so as to realize additional cost savings for the government.

IMPLICATIONS

Because many of the conclusions and recommendations in this research study were predicated on assumptions or data not presently available to the Air Force, a methodology was proposed whereby whereby specific data could be collected to determine the economic advantages of F.O.B. origin over F.O.B. destination terms of shipment. Once exact cost figures are compiled, the Air Force can institute changes in existing contract award procedures to take advantage of potential cost savings involved in F.O.B. origin terms of shipment.

The implementation of the recommendations made in this research study is based upon the following premises:

1. The programs and plans outlined in this study could be implemented within a period of one year at all ALC's.

2. The larger number of F.O.B. origin contracts that would result from the implementation of the recommendations made in this study would involve few, if any, additional contracting or transportation personnel. The expertise and manpower necessary to implement the study recommendations appears to presently exist within the present Air Force contracting system.

A final comment needs to be made concerning the need for the Air Force to exercise "control" over the transporation activity. One benefit of F.O.B. origin terms over F.O.B. destination terms is that the government is in complete control of the shipment--the mode selected, routing, rate negotiation, etc.--from the time the item(s) leaves the contractor's facility until the time the item(s) reaches the final destination. The greater degree of control exercised by the Government under F.O.B. origin terms of shipment also means greater flexibility. By controlling the entire transporation administration function, the Government is better able to expedite shipments when necessary, reroute shipments in transit, change destination points as required, switch to a faster or slower mode of transport if the need for the item changes, and others. The Air Force has highly qualified personnel in the transportation area. Those persons are as competent (and often more so) as their counterparts in the civilian sector, and they can provide equal or higher levels of transportation service. Although it is difficult to assign a cost to the control and flexibility components of the transportation activity, it is apparent that the Air Force can reap substantial benefits in the form of higher levels of service by utilizing the expertise that presently exists in the Air Force transportation work force.

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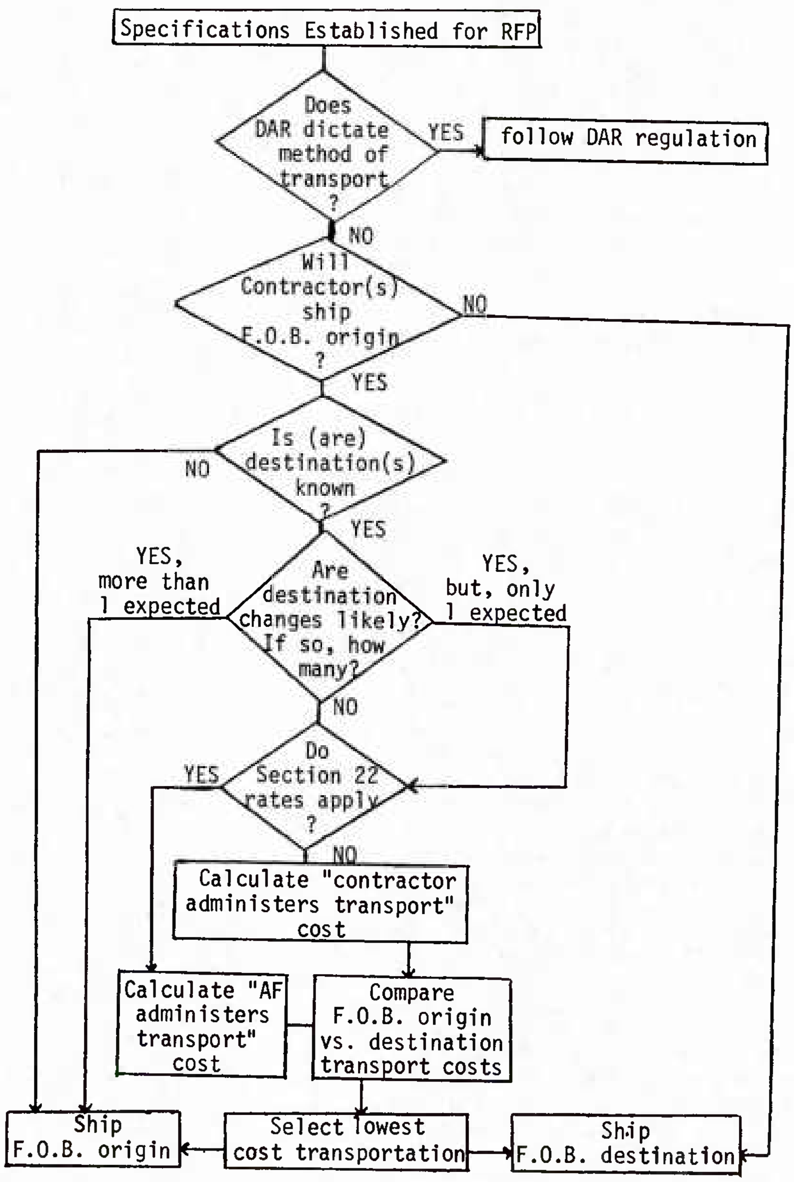
Flow Chart of F.O.B. Origin/Destination Decision



APPENDIX A

INVENTORY MANAGEMENT RESEARCH: SOME RECENT FINDINGS AND NEW DIRECTIONS FOR THE 1980s

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ABSTRACT

Although a tremendous amount of work has been done in the analysis of inventory systems, many important practical issues remain unresolved. In particular, it appears that many of the classical assumptions provide poor approximations to the behavior of military logistics systems. This paper surveys the major findings of several recent studies of Air Force Logistics Command inventory systems and describes major areas in which additional research is needed. Major areas to be discussed include: a) the nature and stability of demand processes for aircraft spares, b) the stability and predictability of procurement lead times, c) control system dynamics and the impact of lumpy data, and d) the role of mission priorities in inventory control.

BACKGROUND

In Reference 3, Presutti and Trepp consider the problem of computing optimum inventory levels in a single echelon, multi-item, stationary, continuous review inventory system. Specifically, they consider the problem of determining order quantities and reorder points for each item so as to minimize total system holding and procurement costs subject to a constraint on either total units backordered or the average number of units in a backorder position. Major assumptions employed in their model include:

1. Demand in the procurement lead time is normally distributed with known mean and variance.
2. The distribution of lead time demand is stationary; i.e., the parameters of the demand distribution do not change as a function of time.
3. The same inventory control parameters will be used in all future periods; that is, the reorder level and order quantity (EOQ) are assumed fixed.
4. Procurement lead times are known and constant.
5. If stock is on hand, demands are satisfied regardless of the priority of the demand. This assumes that no stock is set aside to provide support for future demands for high priority requisitions; i.e., support levels are not used.
6. All inventories are stored at a single location.
7. Book inventories are known and accurate.

By using the Laplace probability density function to approximate the normal distribution, Presutti and Trepp obtained expressions for the optimum order quantity and reorder points. For convenience, we refer to these as the PT-formulas.

Subsequent simulation studies using actual demand histories for Air Force items showed that the PT-formulas were significantly more cost-effective than levels computations then in use: that is, the PT-formulas provided lower levels of backorders for a given investment in inventory than the previous formulas. Conversely, a given backorder level could be achieved with the PT-formulas with a smaller investment in safety stocks. As a result of these studies, the Air Force, the Defense Supply Agency and the Army (for high demand items) currently use the PT-formulas in inventory levels calculations. In the Air Force, these formulas provide the basis of safety stock, reorder level, and order quantity calculations in the Economic Buy Computation System (D062). This system is used to manage over 500,000 items with inventories valued in excess of \$2 billion.

AVAILABLE TOOLS

Two major tools are available to AFLC managers for establishing EOQ procurement budgets for forthcoming fiscal periods. These tools are the Central Secondary Item Stratification (CSIS) and the EOQSIM simulation model. The Central Secondary Item Stratification system estimates required "buy dollars" using a month-by-month deterministic simulation calculation. In this calculation, currently available assets (i.e., stock on hand plus on-order less backorders) are decreased each month by forecasted demands. When available assets drop below the reorder level, the need to procure additional assets is indicated. At this point, on-order assets are increased by the computed buy quantity, and the simulation calculation continues. In this process, aggregate totals are maintained to determine the total dollar value of projected procurements in each future fiscal period.

Although the CSIS is a valuable tool, it does not permit evaluation of alternate supply levels, and it provides no measure of the expected supply

support associated with the projected procurement budget. To relieve these difficulties, an analytical simulation model called EOQSIM was developed. Like CSIS, EOQSIM utilizes a deterministic simulation calculation to estimate the timing and magnitude of procurements associated with a given set of inventory control levels. Unlike CSIS, however, EOQSIM provides the capability to compute and evaluate backorder and fill rates associated with alternative supply levels. To do this, it is assumed that on hand inventories follow a pattern similar to that illustrated in Figure 1. In this figure, it is assumed that demand is a well-behaved random variable. Hence, although on hand inventories do change randomly, they basically follow the level of planned on hand stock shown by the dotted line in Figure 1. During some procurement cycles, demand during a lead time will exactly equal the planned rate. In this case, stock on hand immediately before the receipt of a replenishment order will be exactly the same as the planned level, as illustrated by point A. At other times, demands will be slightly less than planned level. This case is illustrated by point B. Points C and D illustrate cases in which the demands are greater than the forecasted rate. Point C illustrates a situation in which on hand stocks are slightly less than planned safety level just prior of receipt of the replenishment order, while point D indicates a situation in which demands were so high that backorders occurred.

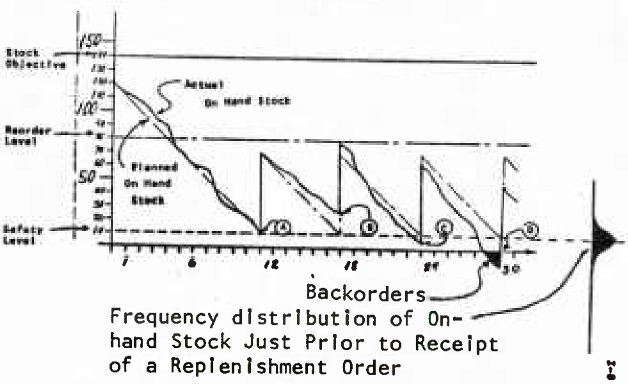

Figure 1. A Sample EOQSIM Calculation.

In the above example, note that it was assumed in all cases that replenishment orders are received at exactly the same times as indicated by the projection of planned on hand stock. (As we will see later, this crucial EOQSIM assumption appears to be a poor approximation to the behavior of many AFC EOQ items).

By observing a specific item for a large number of order cycles, one could develop a histogram of the stock level immediately prior to the delivery of a replenishment order. Such a frequency distribution is illustrated in the right hand margin of Figure 1. Utilizing this distribution, it is possible to compute the probability of a stock out just prior to the receipt of a replenishment order, and the expected number of backorders at this point in time. In developing EOQSIM, the fundamental assumptions used by Presutti and Trepp were used. It was also assumed that on hand stocks followed approximately the pattern illustrated in Figure 1. Analytical expressions were then developed to compute stock out probabilities and expected backorders associated with each future month in a given planning horizon. These formulas were computerized and used to estimate the support effectiveness associated with given sets of D062 items.

Unfortunately, the backorder rates computed by the EOQSIM model appear inconsistent with AFLC supply experience. In particular, EOQSIM often predicts that very high levels of support -- for example, fill rates in excess of 99% -- may be achieved with a very small investment in safety stock. Experience indicates, however, that large investments are required to achieve fill rates as low as 90%.

Why are the EOQSIM predictions so optimistic? What assumptions embedded in the EOQSIM model are poor approximations to the behavior of actual EOQ items? To answer these questions, we performed a number of statistical analyses using historical data from the D062 data system. These studies are reported in detail in (1) and (2). In the next section, we review the major findings from these studies.

RESULTS OF STATISTICAL STUDIES

Figure 2 presents the major assumptions embedded in the EOQSIM support prediction model. The first step in our research was to examine each of these assumptions in detail, and to ask if actual D062 data system information was consistent with these assumptions. To answer this question, several major types of data analyses were performed. Figure 3 presents the major categories of data analysis studies completed. The details involved in each of these studies are documented in references (1) and (2).

After performing the above analyses, we compared our results with each of the assumptions listed in Figure 2. We then classified each of these assumptions as to whether they were good (G) or poor (P) approximations to D062 historical data. Our rating of each of these factors is presented in the left margin of Figure 2. When there was insufficient data to reach a conclusion, we have presented a "?" indicating that more data is needed to judge that particular assumption.

As shown in Figure 2, we found that most of the major assumptions embedded in the EOQSIM prediction model appear to be very poor approximations to the data recorded in the D062 data bank. In particular, we found the assumption of constant average demand with normally distributed variability is a very bad approximation to the characteristics of actual AFLC EOQ demand histories. First, in preparing support effectiveness predictions covering a two or three year planning horizon, shifts in weapon system activities may produce significant changes in the pattern of demands

Figure 2. MAJOR ASSUMPTIONS OF EOQSIM SUPPORT PROJECTION MODEL

QUALITATIVE RATING	MAJOR ASSUMPTIONS
P	1. Constant Average Demand
P	2. Demand Variability is Normally Distributed
P	3. Inventory Supply Levels Do Not Change
P?	4. Lead Times are Known and Constant
G	5. Book Inventory is Accurate
P	6. No Backorders Occur Untill All On-Hand Stock is Shipped
?	7. AFLC Policy is Implemented in A Timely Fashion
?	8. No Demand for Two Years Implies No Future Demand

Figure 3. MAJOR DATA ANALYSES

1. Distribution of Forecast Errors
   - Demand Per Period
   - Demand In Lead Time
2. Zero Demand Study
3. Lead Time Variability
4. Book Inventory Accuracy
5. Distribution of Current Backorders
6. Control Level Variability
7. Relationships of Weapon System Activity and EOQ Demand

for related EOQ items. This problem is particularly severe for new weapons that are being phased into the inventory and for obsolete systems that are being phased out. Unfortunately, as shown in (1), the relationship between weapon activity and EOQ demand patterns is not precise. However, it appears that major errors may result if significant changes in program activity are not considered in budgetary and support effectiveness predictions.

A second major finding concerning EOQ demand processes was that AFLC EOQ demands have more variability than implied by the P-T-formulas. Actual D062 demand histories appear to be much more "lumpy" than would be expected from a normal probability model. This lumpiness is probably caused by the fact that AFLC depot customers often requisition large quantities of items at a time. This may then be followed by a period of several weeks or months in which there are no demands at all placed upon the depot level supply system. In contrast, a "normal" demand model assumes customers of the supply system place orders for only one unit at a time, and that there are a large number of such customers.

The lumpiness of AFLC demand patterns implies that calculated supply levels may change very significantly over periods as short as a one year time period. Hence, assumption 3 is also a poor approximation to D062 processes. For example, suppose that an item has had no demand for two years. Suppose that one requisition for 800 units is then placed against the supply system. The two year moving average of demand for that item would then immediately jump to 400 units per year. Suppose that two more years now elapse with no further demands placed on the system. The demand rate estimate would remain at 400 units per year for two years. At that time, the estimated demand rate would immediately fall to zero.

Although this is a fabricated example, demand patterns which produce significant jumps and drops in reorder levels may be found throughout the EOQ demand history tapes. Figure 4 illustrates this effect for a particular D062 item. Many similar plots are presented in Reference 2.

FY - 71-72 DEMAND AND RETURNS

KNT- 73
SM L5 156052 042 EA 112.63BRACT AS 2 968 76. 0. 1. 6.

QTR	1	2	3	4	5	6	7	8
DEM	10.	2.	8.	6.	12.	4.	4.	4.
RET	0.	5.	0.	1.	5.	3.	0.	1.

ROL = 8
EOQ = 24
EOQ + ROL = 32

FY - 73-75 DEMAND AND RETURNS

QTR	9	10	11	12	13	14	15	16	17	18	19	20
DEM	2.	4.	3.	3.	1.	4.	1.	2.	13.	7.	3.	4.
RET	2.	4.	1.	3.	1.	0.	0.	1.	0.	0.	1.	0.

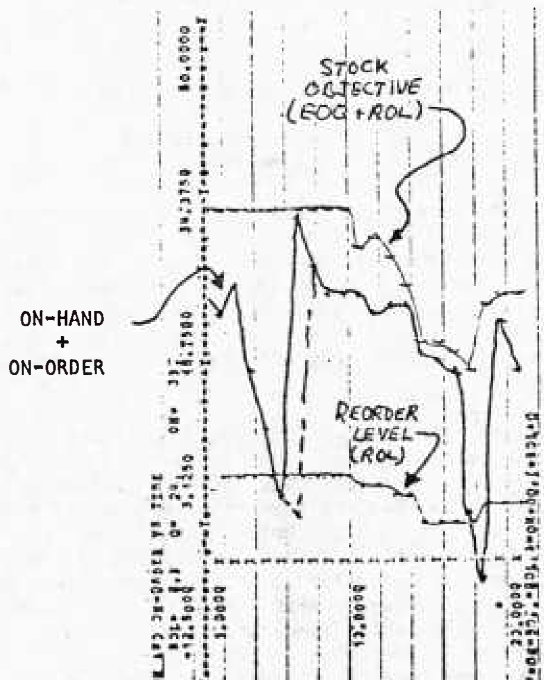

Figure 4. Control Levels Verses Time for FSN 165062042 for FY71-FY75.

As shown in Figure 2, the EOQSIM model assumes that procurement lead times are known, constant and accurate. We found it very difficult to obtain historical data on actual lead times. However, we were able to collect lead time data on a sample of ten items. This data included the predicted and observed lead times for all procurements of these items during the 1974-1979 interval. Figure 5 presents the ratio of actual to predicted leadtimes that we obtained from this data. This is of course too small of an item sample to reach conclusions concerning all of the AFLC inventory. However, this data indicates that the assumption of known and constant lead time is a very poor approximation to historical data. Consequently, we have ranked assumption 4 with a "P?", indicating that this assumption appears to be a poor description of what actually happens, but that insufficient data is available to determine a better model.

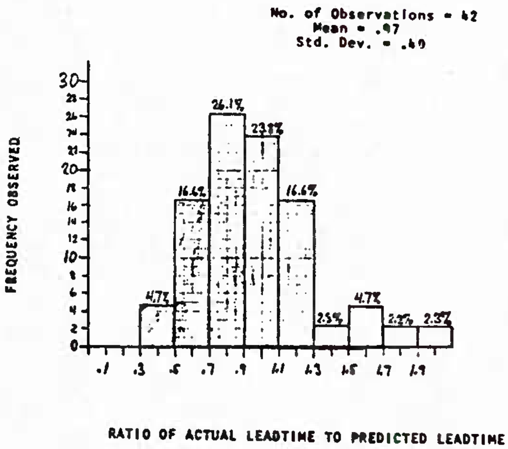

Figure 5. Distribution of Normalized Leadtime Forecast Errors.

The fifth assumption listed in Figure 2 is the assumption of an accurate book inventory. This appears to be a good approximation for the D062 system. We reviewed listings of unit and dollar adjustments made to D062 inventory records during 1978. Based on these periodic physical counts, it appears that EOQ book values are quite accurate.

The sixth major assumption listed in Figure 2 is that no backorders occur until all on hand stock is shipped. This implicitly assumes that either (1) all demand has the same priority, or (2) that fill rates are so high that essentially no backordering takes place. We found (1) and (2) to be a poor approximation to D062 backorder records. For a large number of AFLC items, on hand stocks and backorders exist simultaneously. In fact, distribution levels are computed to guarantee this effect; that is, these levels are computed to reserve a certain level of stock for high priority demands only. When stock levels fall below this level, low priority demands are backordered, even though there is on hand stock.

Another major EOQSIM assumption is that AFLC policy is implemented in an accurate and timely fashion. This assumption is necessary if one is to predict the quantities ordered when reorder levels are breached, the time these orders are placed, and the procurement and administrative delays involved. We were unable to locate any data for testing the accuracy of this assumption. However, discussions with AFLC/LORRA and AFLC/XRS personnel indicated this is a reasonable approximation to AFLC operations.

Finally, a major assumption embedded in both CSIS and EOQSIM is that if there has been no recorded demand for an item in the past two years, then there will be no future demand for that item. We found that for items with no demand in two years, there is a 6-8% chance that there will be at least one unit of demand in the next quarter. In addition, there is a 6-8% chance of demand in the following quarter, and in the quarter after that, and in any future quarter. Our qualitative rating for this assumption is a "?". Obviously, an occurance rate of six to eight percent is different from zero percent; however, whether or not such a probability of occurance leads to any significant change in predicted backorder or fill rates is yet to be determined. If items with "zero demands" also tend to have one or two units of stock on hand, there will be practically no effect on predicted backorders and fill rates. However, if "zero demand" items generally have zero on hand stocks, ignoring the six to eight percent quarterly demand probability could produce large errors in backorder and fill rate predictions. To evaluate the significance of the "zero demand" assumption, additional data is needed describing the distribution of on hand stocks for these items.

NEW DIRECTIONS FOR THE 1980s

Our research has shown that many of the commonly accepted inventory management assumptions provide poor approximations to Air Force inventory control systems and demand processes. Consequently, although the standard techniques have served as well, we believe that significant improvements are possible through the development of inventory control and support effectiveness formulas tailored to the unique features of the Air Force environment. Consequently, several efforts have been initiated to develop these refined techniques. First, several additional data studies are currently underway. These studies will improve our knowledge of the accuracy and variability of requisition processes and of forecasts of item lead times and demand rates.

An improved support-effectiveness prediction model -- the Son of EOQSIM -- is now being developed, and a prototype is currently operational. This model considers the impacts of changing weapon programs, control system dynamics, lumpy demand, requisition priorities and several other factors in projecting the budgetary requirements and associated support effectiveness of proposed Air

Force programs. Finally, we believe that our new understanding of Air Force EOQ inventory processes will provide the basis for new inventory control formulas which will be even more cost effective than the Presutti Trepp formulas.

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PROCUREMENT AUTOMATION AND MIS

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FOURIER ANALYSIS

A MODERN ANALYTICAL TECHNIQUE

A BREAKTHROUGH TO HIGHER PRODUCTIVITY

Melvin A. Mallory: Defense Contract Administration Services Region, Chicago

Russel W. Duvall : Monogram Models, Inc. - Division of Mattel, Inc.

ABSTRACT

The goal of this paper is to outline a totally new method of implementing a well-known approach to Performance Improvement, and to solicit comments from, and discussion with, academicians and practitioners of the art and science of management.

By taking an established technique from the Physical Sciences, Fourier Analysis, and applying it to the Management Sciences, the authors have discovered what appears to be the key to a much-needed major breakthrough in performance improvement and in management's ability to manage.

Analogically, the approach sees:

Performance Improvement as the

"Engine" of Progress

Believable Standards as the

"Timing" of Performance

Fourier Analysis as the

"Timing Light" of Standards

PERFORMANCE IMPROVEMENT

Performance Improvement is widely hailed as the best hope for revitalizing this country's rate of progress. This paper uses an approach to achieve this goal which has the following Primary Assumption and Basic Premises:

Primary Assumption. Most people want to do a good job and will put forth the effort required to meet and exceed their previous best performance if they are convinced that:

a. The work they are doing is important.

b. They are being considered as individuals.

c. They will not harm themselves or their co-workers by their improved performance.

d. The systems being used to measure performance are "fair" and take into account all critical variables.

Much has been written concerning points a, b, and c. This paper addresses point d.

Basic Premises.

1. The greatest potential for achieving the major breakthrough rests on management's ability to obtain improved performance from people even more than from machines.

2. A method which uses the present level of output as a guideline or standard will incur the fewest challenges since this level has already been achieved.

3. A method which encourages employees to exceed their own previous best performance circumvents the difficulty encountered in using arbitrary or "engineered" standards. This difficulty is that the employees do not understand, accept, nor identify with these "imposed" targets.

4. Any viable method, regardless of the source of the figure used as the standard, must have a means of demonstrating the validity (or lack thereof) of the standard itself. It must be able to document that the present conditions are, or are not, identical to the conditions which existed when the standard was established.

BELIEVABLE STANDARDS

The usefulness of accurate, believable standards need hardly be discussed. A range of activities, from budgeting to performance evaluation, take, as a base, some form of standards. It is difficult to imagine how an operation of any size and complexity could function as effectively without them.

Yet, regardless of how they were established, the standards themselves are constantly "under the gun". This is particularly true whenever a supervisor or manager is questioned about sub-standard performance. In fact, there is an almost universal response: "The standard is no good."

The difficulty seems to be that standards have come to be viewed as something which they were never intended to be--arbitrary, insensitive, unrealistic taskmasters. In fact, all a standard is supposed to do is to state an expected level of output per unit of input or a required level of input per unit of output GIVEN that the conditions have not changed.

And therein lies the Achilles Heel of standards, for, indeed, conditions do change, with frustrating regularity. Without continually monitoring each empirical element of work performed by each employee, it has been impossible for a superior to state, categorically, that the conditions during the period of measurement of performance were identical, in all significant respects, to the conditions under which the standard was established.

Use of the present level of output as the standard, obviously, avoids the problem of arbitrariness. This is, however, only the starting point. Unless the present level of output is equal to the ultimate, management must design programs which result in exceeding this standard. These programs may carry monetary rewards, but this is not absolutely required. Numerous studies have shown that, for many employees, objectives other than money have great motivational power.

The choice of standards deserves attention, but far more important is the ability to detect a change in conditions. To fully understand the complexity of this problem, it is necessary to consider the two basic work environments: "Machine" (hereinafter called "M") and "Administrative" (hereinafter called "A"). These are defined, respectively, as: "Equipment-paced", industrial, assembly line type operations, and "people-paced", non-industrial, paperwork, office, general type operations.

In a typical "M", the rate of production is established by the speed of the production line. The amount of effort required is in direct proportion to this speed or pace. If a line, for example, produces 100 units per minute and an operation performed on each unit requires 0.1 manhours (MH), then 10 MH of effort will be expended for each minute that the line runs at standard. As a result, 100 units will be produced per minute, each unit carrying 0.1 MH of labor expense.

If the production output falls below standard, the first check made by the supervisor is to ensure that the line is running at a rate of 100 units per minute. If the labor cost per unit increases above standard, the first check made by the supervisor is exactly the same. The second check made is to determine if the operation is still being performed in 0.1 MH per unit. If he finds these to be in order, the supervisor turns his attention to other possible causes--scrap, downtime, rework, etc. The point is that the supervisor first checked to ensure that the standard was still valid. This is fairly straight-forward in an "M".

Not so, however, in the "A". This is due, primarily, to the fact that, in an "A", the speed or pace of the "line" cannot so easily be determined, and, even more significant, the amount of effort required on each "unit" of work can vary from practically nothing to thousands of manhours. The very definition of a "unit" of work is not always clear.

Although this would appear to make the validation of standards nearly impossible in an "A", another factor can be borrowed from the "M" to assist in understanding and controlling the "A".

"It Sounds Right". There is a phenomenon well-known to every mechanic. Using the analogy of the automobile engine, when the mechanic is faced with an engine running improperly, he first checks the "timing". Finding it to be correct, he turns his attention to other possible causes. He has, in effect, "validated the standard".

After adjusting the other components and having brought them into proper balance, the mechanic will say the engine "sounds right". The sound he is referring to is the "signature" or "tone" of that engine running at standard. It is not difficult to explain the generation of this "tone" in an "M". The combination of explosions, pulleys, gears, chains, belts, etc., create a unique sound signature, a summation of the sounds of the empirical events. The waveform of this unique "tone" can be displayed on an oscilloscope, and the "index" of the "tone" can be seen by flashing a timing light on the "notch" on the timing gear.

This phenomenon is not unknown to many managers and supervisors in a wide variety of work environments. It is often expressed as a "hum", as in "Things are humming". It is the "hum", "sound signature", or "tone" that the supervisor is listening for when he steps onto the production floor. If it is present, he knows he can turn his attention to other matters. He doesn't even have to look at the gauges. Conversely, if it is absent, or if the "tone" he hears is different from the standard "tone" which he has filed in his memory, he knows he must investigate, because, appearances to the contrary notwithstanding, conditions have changed--and probably for the worse.

This phenomenon also exists in the "A". The difficulty is in measuring it. There is no "notch" upon which to flash a timing light, nor anywhere to attach an oscilloscope.

FOURIER ANALYSIS

Progress of Research. During the years 1968-1975, several studies were conducted in an attempt to find a Common Denominator in the work of Quality Assurance Representatives (QARs) at the Defense Contract Administration Services Region (DCASR), Chicago. Reports of these studies are available through contact with the authors (1) and from the Defense Logistics Studies Information Exchange (2).

An interesting finding of these studies was the recurrence of two types of events or actions. One of these was calculated as requiring 25.2 seconds. The other required approximately 1/4 of this time or 6.0 seconds. Efforts to identify these events were pursued during Management reviews of field activities and visits to contractors' facilities. However, the research was, for the most part, overlooked.

One of the histograms, Figure 1, from these studies continued to interest the researchers. This histogram displays the number of facilities (on the Y axis) which required a particular average amount of time to perform a product inspection observation (on the X axis). The data is from the period January-March, 1971.

The wide variation of the data rendered it useless in attempting to establish a performance standard which could be expected to remain within acceptable tolerances.

Three characteristics of the histogram are most significant. First, there appears to be an exponential curve in the data. Second, there are a number of major and minor "spikes". Third, there exists a definite and patterned "lobing" or periodicity in the data.

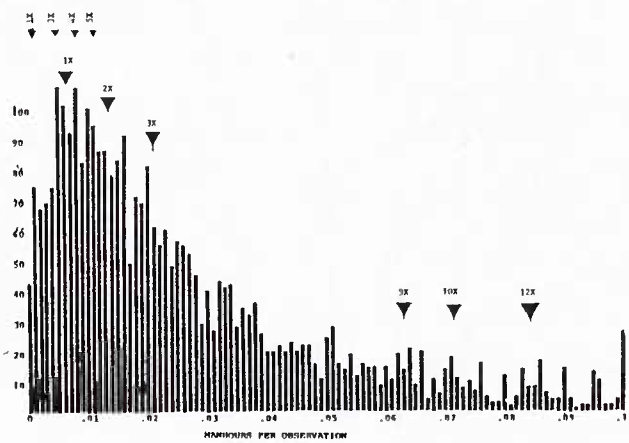

Figure 1

The periodicity brought to mind the possibility of using some variation of the calculus to further investigate the data. The striking resemblance of the histogram to the waveforms seen in the study of signature characteristics of electronics equipment led the researchers to the Fourier analytical technique.

The French mathematician and physicist, Baron Jean Baptise Joseph Fourier, 1768-1830, developed the Fourier series over 150 years ago. This technique expands a periodic function into a series of sines and cosines. Extensive and exhaustive treatments of the details of the Fourier analytical technique can be found in numerous textbooks.

The Fourier formulae, the conditions required for the Fourier series to converge, and some cautions concerning its use are listed in the Appendix. Fourier Analysis is regarded as a touchstone method for describing the periodicity of waveforms.

The laborious calculations required to manually "run a Fourier", however, severely limited this technique as a viable research tool at that time. In 1977, a Fourier program became available on the GE Time-Share computer installation at DCASR, Chicago. This program is catalogued under the title "FINT".

Between 1975 and 1977, however, the definition of the "Product Inspection Work Count" had changed from "observation" to "sample unit". The method of inspecting remained the same. Only the method of counting and reporting had changed.

On the assumption that this change and the lapse of time would have made the 1971 data obsolete, a new study was made using data from the period March-September, 1977. The histogram of this data is shown in Figure 2.

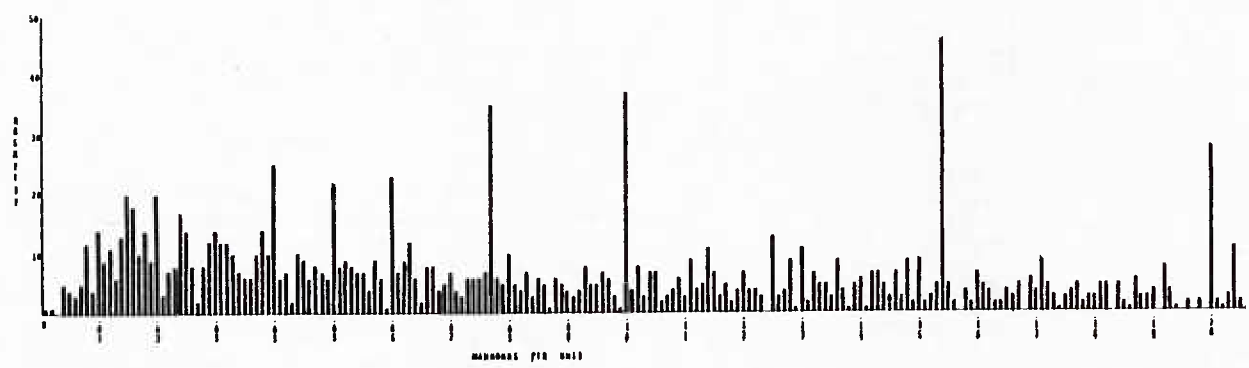

Figure 2

The most immediate characteristic noted was the apparent total lack of an exponential curve. The "spikes" are present, with the major "spikes" being even more dominant than in the 1971 data.

Note: Closer investigation of these revealed that their occurence coincides with the ratio of a small number of hours to the minimum standard sample sizes directed in MIL-STD-105d, and probably relates to the activity of non-resident QARs in small contractor facilities.

Of primary significance, the "lobing" or periodicity is still present in the data. It was, therefore, decided to submit the data to the Fourier technique. In order to do so, a Calling Sequence had to be programmed. This was done and is catalogued in the GE Time-Share library under the title "PERFORM".

The "PERFORM" sequence is used when the unit of time per unit of work is greater than 1. The data at hand, was, however, recorded in Manhours per Unit Inspected, and the values were 0.2 or less, making the use of "PERFORM" impossible. A second Calling Squence was programmed to circumvent this problem by multiplying each hour value by 3600, thus converting the file from manhours to seconds per unit. This Calling Sequence is catalogued under the title "SPEC".

The limits of integration were arbitrarily set at -25, +25, and "SPEC" was run. It produced Figure 3. The periodicity of the waveform is apparent, but the series has not yet converged, indicating that an adjustment to the limits of integration is necessary.

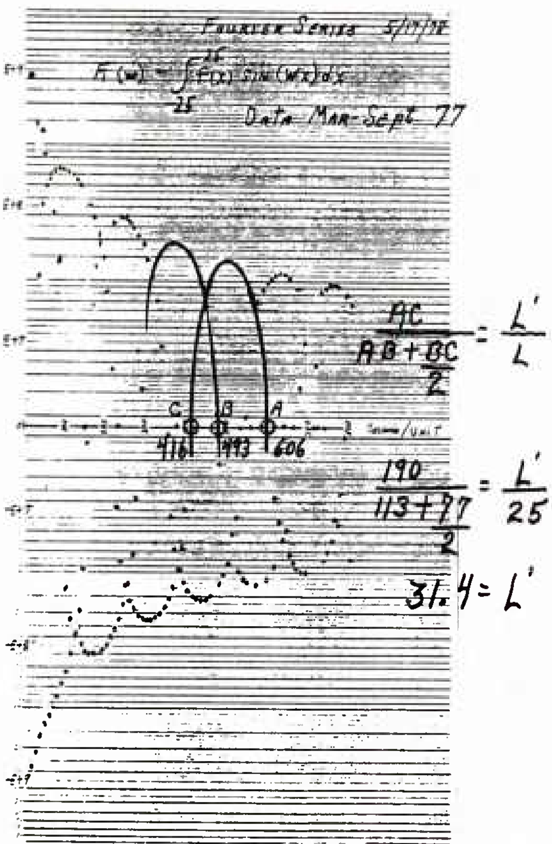

Figure 3

It is possible to calculate the adjustment from the plot in Figure 3. As a result, the appropriate limits of -31.4, +31.4 were derived. These were set, and "SPEC" was run again. The result is Figure 4. The series has now converged, and the calculation of the interval or "integer" can be made as shown in Figure 4. This "integer" has a value of 6.3057 seconds.

The close adherence of this value to the shorter event or action detected in the 1971 data was encouraging. Continuing the research, another set of limits was arbitrarily chosen at -12.5, +12.5, and "SPEC" was run again. The result was another partially converged series similar to Figure 3. The adjustment calculations were made, new limits of -15.7, +15.7 were set, and "SPEC" was run once more. The result was a fully converged series, similar to Figure 4. When the "integer" was calculated, the resultant value was 25.223 seconds.

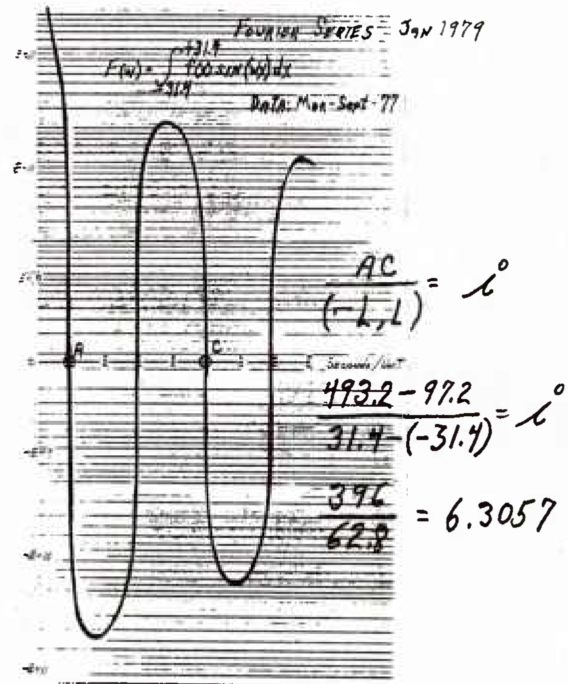

Figure 4

By reflecting on a typical "inspecting" environment, a plausible explanation can be advanced for the existence of two integers. In the act of inspecting", there are two basic categories of events -- "looking", i.e., visually checking the sample unit for the presence or absence of a characteristic and "subjecting", i.e., taking readings through the use of some type of gauge or measurement device. It is reasonable to postulate that the "looking" action would require less time than the "subjecting" action, and, therefore, that the integers of 6.3057 seconds and 25.223 seconds would correspond to "looking" and "subjecting", respectively.

Note: Additional Fouriers were run in an attempt to determine if there were other integers present in the data. These proved futile.

One Small Step Backward--A Giant Leap Forward. The verification of the existence of these two integers in the 1977 data led the researchers to resurrect the 1971 data. Although the method of reporting work count had changed, since the method of inspecting had not, it was reasonable to expect that, if the hypothesis was valid, these two integers should be identifiable in the 1971 data.

Running "SPEC" on the 1971 data with limits set at -31.4, +31.4 yielded a fully converged series and an integer of 6.4203 seconds, as compared to the 6.3057 seconds from the 1977 data.

Running "SPEC" on the 1971 data with limits set at -15.7, +15.7 yielded a fully converged series and an integer of 25.223 seconds -- identical to that produced from the 1977 data!

Note: There were some minor ripples apparent in the waveform indicating that the limits were not exactly correct. The interesting point is that there is some tolerance in setting the limits.

The plot produced from the 1971 data with limits set at -31.4, +31.4 is shown in Figure 5. Comparing Figures 4 and 5, one can see the similarity.

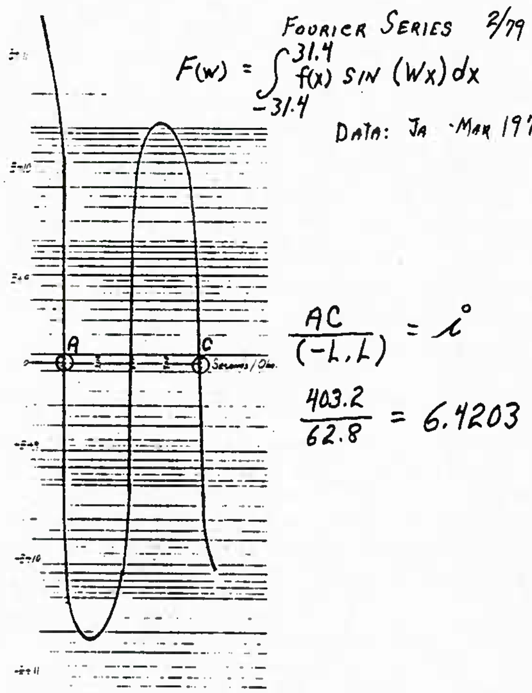

Figure 5

Numerical Concurrence. The limitations imposed by manual plotting and the need to make readings from these plots are certainly recognized. However there is a striking correlation between the plots, even in the strength of the waveforms. Using data from the computer readout, not the plots, a peak in the positive cycle of both plots occurs at 385.2 seconds. The amplitude of the peak in the 1971 data is:

1.1127321 times E(+11)

That of the 1977 data is:

1.1126562 times E(+11)

The variation is 0.007%.

The corresponding plots of "SPEC" with limits set at -15.7, +15.7 reveals the same concurrence of strength, but on the negative cycle of the plots. At 360 seconds, the 1971 data shows a peak with an amplitude of:

1.7585262 times (E+4)

In the 1977 data it is:

1.7585576 times E(+4)

The variation is 0.002%.

Both of these sets of waveforms are virtually identical, indicating that both sets of data contained the information about the QARs' mix of visual/mechanical and gauged/measured characteristics, and that the average time to do them had not changed significantly in six years!

Additional Research. Desirous of confirming the validity of the hypothesis in different work environments, the researchers turned to two other areas within DCASR, Chicago. The first concerns the work of Engineers providing Technical Assistance on Cost Proposals (TACPs). The data is taken from TACP logs and is recorded in Manhours per TACP Completed. The histogram of this data is shown in Figure 6.

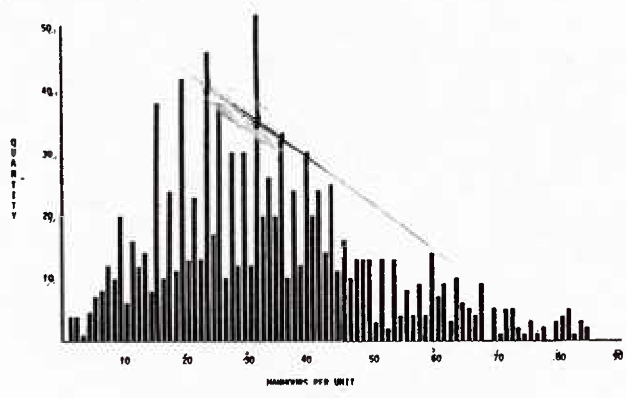

Figure 6

Once again, two of the three characteristics are evident. There is no apparent exponential curve, but the "spikes" and the periodicity are there. Upon submitting this data to the Fourier technique, two integers were calculated--slightly less than 2 hours and slightly less than 8 hours.

Note: Further investigation of the data revealed that over 70% of the recorded TACPs required a multiple of 2 hours to complete. This was the pattern of the data. The Fourier technique had to pick it up.

Once again, thought was given to finding the work cycle which required 2 hours or 8 hours. However, the investigation into a second area shed light on the most probable meaning of these two integers.

The second area was Pricing Analysis--the work of Price Analysts examining contractors' proposals. The data was calculated from the total Manhours expended per proposal analyzed. Two integers were calculated--slightly less than 2 hours and slightly less than 8 hours. At this point, a probable explanation became clear.

A typical work day is 8 hours long and is broken into four 2 hour segments. A review of the data lends credence to this explanation. The problem is, therefore, in the definition of the "work unit" and in the method used to evaluate how much "work" has actually been accomplished.

It is obvious that a more refined definition of the "work unit" must be found. The application of the Fourier technique can yield such a result. By taking various parameters which differentiate between pieces of the work and using them to set the "work unit" and measure the effort expended, it can be expected that the basic rhythmic work pattern will be found in these environments.

Once found, these integers will serve as the "indices" to the levels of output at that time--the standards. From that point on, levels of output can legitimately be measured against these standards as long as the "indices" remain constant. Conversely, when the "indices" change, the standards should be reviewed and adjusted.

APPLICATION

The application of the method, interestingly, does not require that the specific action or event be identified--the action(s) which the integer(s) will be quantifying. The potential which the researchers perceive in this method rests, instead, on proving that the integer is constant when the work pattern is constant, and changes when the work pattern changes. If this can be proved, the means of validating standards will be found!

By "running a Fourier" on data representing the work being done by a group of employees, a waveform should result in an "integer". The "integer" will be the "index" of the "tone" of the environment at that level of output. If the integer remained constant, it would be reasonable to expect output equal to the present level as a minimum. By routinely calculating the integer, management would know if and when adjustments to the standard should be made. Likewise, a constant Fourier integer would be prima facie evidence that any variation in the level of output would have to be explained by other means than, "The standard is no good."

SUMMARY

Although most of the research has been concentrated in the "Administrative" environment, this does not mean that this method cannot be applied to the "Machine" environment.

Even if the method could not be utilized in the "Machine" environment, in light of the large percentage of this nation's workforce now employed in "Administrative" environments, and the realization that, in many instances, even "Machine" environments are controlled by the pace of the people who operate them, this possible limitation is not viewed as a significant constraint on the value of the method.

It is the authors' belief, however, that the first major breakthrough will come through the application of the method in an "Administrative" environment.

Extensive research remains to be performed on data from a broad spectrum of work environments if the hypothesis is to be confirmed. However, utilization of the method need not wait until all this research has been completed.

Concentration in an industry or a portion of the Government could produce sufficient proof to allow design and implementation of programs which would yield a tangible payback in the very near future.

The approach seeks to make continual, meaningful, and permanent gains in productivity. It does not expect to make a quantum leap one month only to suffer a major setback the next. That approach spends tomorrow's resources for today's gains. When tomorrow arrives, the resource vault is empty and the debt remains to be paid.

Such an approach is an exercise in futility, and any gains will be temporary. Further, the lasting negative impact on employees' morale, and, more significantly, their confidence in management's competence and sincerity cannot even be calculated.

The proposed approach accepts that most people want to do a good job, and the method outlined provides the rationale for employees, supervisors, managers, and executives to believe the standards. They can then measure themselves objectively versus those standards. By finally putting to rest the questioning of the standards themselves, management can concentrate their attention on ways to improve performance, continually confirming, to the satisfaction of everyone concerned, that their system of measuring that performance is still valid.

It is impossible to imagine a mission element or a work activity that does not have a "Signature" or "Tone". Fourier Analysis may well show us the notch to check the "timing" and the computer programs PERFORM and SPEC will show us where to attach the oscilloscope. The rest of the "Story of Progress" is up to us as managers and directors.

ACKNOWLEDGEMENTS

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APPENDIX

Fourier Formulae

$$F_1(W) = \int_{-L}^{L} f(x) \sin(Wx)dx$$

$$F_2(W) = \int_{-L}^{L} f(x) \cos(Wx)dx$$

Dirichlet Conditions

(1) f(x) is defined and single-valued except possibly at a finite number of points in (-L, L)
(2) f(x) is periodic with the period of 2L
(3) f(x) and f'(x) are piece-wise continuous in (-L, L)

Then the series with the sine or cosine coefficients converges to f(x) if x is a point of continuity, and f(x - 0) + f(x + 0) if x is a point of discontinuity.

Cautions in Use of "PERFORM" & "SPEC"

The period set for (-L, L) must be within reason. An excessive period results in a requirement for a float data accumulation which may exceed the capability of the computer.

x Values should be greater than 1. Decimal values cause the product of (W*H) to be less than .007 (program restrictions).

f Values should be greater than 2. 1 Causes the computer to hang-up in a warning mode. 2 Causes the F value to approach zero.

Data variations caused by alizing (irrelevant sources) do not affect the results.

It is only necessary to plot sufficient data to determine the cyclic patterns of F(w) and to calculate the proper values of (-L, L).

LAMIS - A WORKING, EFFECTIVE PROCUREMENT MANAGEMENT INFORMATION SYSTEM

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ABSTRACT

This article describes a uniquely efficient yet universally applicable procurement management information system. The Data Base, processing procedures, reports and capabilities of the system are discussed. The query system and the work load measurement capability are featured. The system is responsive and dynamic and consequently constantly changing to meet the needs of the current environment. Future plans to accomodate these changes are mentioned. Finally the experiences of implementing the system are cataloged in a summary of lessons learned.

LAMIS - Early in 1971, the USAF's largest Research and Development Contracting Organization gained approval to develop a Management Information System (MIS). The system developed was named "LAMIS". The "L" means little in deference to the USAF AMIS (Acquisition Management Information System). The word "little" is nondescriptive, however, since the system is relatively large currently consisting of over 27 million stored characters of information and over 100 programs. It is also extremely sophisticated, flexible and indispensable for the effective management of the high volume contracting environment of Aeronautical Systems Division Directorate of R&D Contracting.

This article will describe the evolution and the operation of the LAMIS. It is written with the objective of presenting a real world example of a very valuable and useful system, some reasons why and how it got that way, and some basics that should be helpful for planning and implementing a similar system.

The LAMIS is not a purchase request (PR) tracking system. It can more accurately be described as a total contractual work load tracking system since it involves all phases of the contracting cycle from receipt of the PR to the ultimate closeout of the contract. Obviously, this cycle can be of several years duration. The need for such a system can be evidenced by the FY78 R&D Contracting statistics which reflects over 2500 PR's processed, over 4400 contractual documents distributed, over \$310 million obligated, over 3900 contracts administered with over 500 contractors ... need is the mother of invention here. LAMIS, through its effective data base and reporting capabilities, is indeed vital to the management of this complex operation.

DATA BASE. The LAMIS data base consists of four main data files that previously existed as manually maintained files. These files contain data relative to and identified as PR, Solicitation, Contract and Post Contract Files.

The data from the manual files and records were placed on magnetic disk storage on the computer. The fact that the files are on computer disks allows the entire LAMIS data base to be available for inspection or query at all times.

The computerized data files are composed of fixed length records and the size of file has reached a steady state of approximately 27 million characters. After the end of each fiscal year, all the contracts that have been retired are removed from the LAMIS data base, PR and solicitation data records associated with the retired contract are also removed from the data base. This data is not lost, but is archived on microfiche for future referral and storage.

The programming of LAMIS has been accomplished via contract and in-house with the support of the ASD computer center. LAMIS currently constitutes 205 programs used to perform file maintenance and produce output products.

The majority of these programs are written in Common Business Oriented Language (COBOL). A few of the programs utilize Formula Translation (FORTRAN) routines to handle the mathematical computations that are beyond the capabilities of COBOL. Since the programs were originally written they have been continuously modified, maintained,

and updated by in-house contract analysts who have a background in contract negotiating and a knowledge of computer programming. As a result, we have a "time-tested" set of programs. Some 54 programs are devoted to updating and maintaining the data base; 51 programs are used to produce 25 output products. The word "little" is certainly a misnomer.

All data input to the data base is subject to a series of validation checks before the data is entered into the file. After the files are updated, a series of analysis checks are made against the entire file. The validity and credibility of data comprising the LAMIS data base is consequently maintained at a very high standard.

Processing. Currently, LAMIS is not a "real-time" system; plans are in being to integrate LAMIS with an automated contract writing system and subsequently provide a "real-time" capability. LAMIS is now updated on a weekly basis. The updating and file maintenance programs are run on Friday afternoon and the reports program are run over the weekend to provide accurate up-to-date information to the users on Monday morning.

Data input to LAMIS originates from several sources within the buying organization as well as other organizations related to the contracting function. These sources include the PR control office for PR data, the buyers for the solicitation file, AMIS for the contract file, and field offices (DCAS, AFCMD) for the post contract file. Input methods used are keypunched cards, cathode ray tube (CRT), communicating magnetic card typewriters, and magnetic tape.

The output products are available via several different mediums. Paper is used for recurring reports, unique reports can be displayed on paper or on a CRT, and microfilm is used for archived type data. Punched cards and magnetic tape are available options for output but are not currently used.

The use of microfilm is a highly efficient medium for storing large quantities of data. It costs approximately three cents to produce a 4" x 6" sheet of plastic that contains the equivalent of 270 sheets of paper.

Reports. The most visible capability of LAMIS is the products, mainly, the hard copy management reports. These reports are produced for and used by all levels of management in the buying organization. They are also used by the supported organizations. These include the laboratories, Accounting and Finance Office, Legal Office, Information Office and higher headquarters.

The number of reports is kept to a minimum. Currently, LAMIS produces some twenty-five scheduled/recurring reports. Only nine are produced on a weekly basis. The remaining are on a monthly and quarterly basis.

Additionally, LAMIS has the capability to produce "special" one time reports in response to peculiar requests. In all the "management by exception" rule is followed and reports are kept as small as possible in an easily understood clear text format. An example of a report produced by LAMIS is the weekly "Management Report." This report is produced for each level in the organization, i.e., Director, Division, Branch, and Buyer. At each level it reflects only the cumulative data to that level. It is a one page report containing ten basic areas of management information that summarizes the R&D contracting process. It reflects the procurement-initiator interactivity, procurement activity, and procurement-contract administration interactivity. It takes the continuous contracting process and delimits it so that management will be able to observe the procurement process within a fiscal year time frame. Using this report, managers are able to perform trend analysis, comparative analysis, and work load management. The result being that the manager is better equipped to deal with the customers, superiors, and subordinates and "manage" the overall operation.

An understanding of this report places a very powerful tool in the manager's hands. It provides a degree of visibility into the total operation that is sliced at each organizational level from buyer to director.

It was mentioned that LAMIS is useful to all organizational elements. An example of its use at the Buyer level is the "Buyer Report." This report is produced on a weekly basis for each open solicitation. It gives the buyer a visible status report of his work and helps him track his solicitations to completion through the solicitation network. This same data is provided to upper levels of management. By exception reporting only those actions that are 90 days old and older are displayed. LAMIS also provides information to the buying activities' customers. As an example, the "Lab Report" is issued monthly to all the Laboratories, it lists all contracts that have become delinquent or will be delinquent within the next 30 days. The objective is to encourage the project engineer to follow up on the submission of final close-out documentation on the contract.

Query Capability. A functioning management information system must also have the capability to respond to real questions rapidly. LAMIS has two on-line query capabilities that allow the entire data base to be readily accessed.

One of the capabilities is the "SHAZAM" program which will display a preformatted output on the CRT in response to a one position code and document number entered by the initiator. The method of input is very easy and the response quite rapid; consequently, the SHAZAM program is used for the majority of inquiries. There are five different preformatted displays that may be called

for by entering the one position code. Code "P" calls for the Purchase Request format, Cose "S" the solicitation format, "C" the contract format, "M" the contract modification format, and "K" the post contract format.

The data items included in each format have been tailored to satisfy the types of short questions directed to the operations office by telephone. These questions usually pertain to a specific document. A typical call would be "I need to know the name, office symbol, and telephone number of the project engineer on Contract F33615-75-C-1344." A clerk would enter the code "C" and the contract number and within a few seconds the preformatted contract information would be displayed on the CRT screen. The display will contain more information than was requested, this is by design. Frequently, the caller will ask for additional information after his first question is answered. The purpose of the SHAZAM program is to provide instant information without having manual files maintained on PR's, solicitations, contracts and post contract data. The second capability for accessing the LAMIS data base is through a program called "VENUS". The VENUS program is much more sophisticated than the SHAZAM program and it is also more complicated to use. VENUS allows updates to be made to the data base as well as supplying output in response to queries. Unlike SHAZAM, the VENUS queries are not preformatted, but instead are quite flexible to the need of the query. VENUS may be asked to supply data on a specific document or it may be asked to provide lists of data for groups of documents or summary data for groups of documents.

An example of a request to be satisfied by VENUS would be "list all the contracts in the system by contract type and provide a count of documents and a subtotal of obligated dollars by contract type and a total count and total summation of obligated dollars for all contracts". Since each query is formulated to satisfy a unique request, the user must have an intimate working knowledge of the LAMIS file and record configuration to be able to construct a VENUS query. Thus, VENUS can access the LAMIS base totally and is only limited by the user's expertise.

Tracking Network. LAMIS is a contractual action oriented system; it is helpful to think of it as such, rather than just a PR tracking system, since LAMIS works just as well without PR's. Each type of contractual action performed within the ASD Directorate of R&D Contracting has been categorized into a PERT type network. For example, a competitive negotiated procurement estimated between $90,000 - $1,000,000 is assigned a predetermined network (B1); likewise, a sole source negotiated procurement less than $90,000 is assigned a different network (B4). Currently, there are seventeen different tracking networks that represent all the possible contractual actions experienced in this organization. These networks are relatively easy to establish and can be tailored to any contractual action.

To further understand how this works, let's examine the B1 network (See Fig 1). The nodes are events that end an activity, the arrows represent the span of time that the activity is taking place. The numbers within the nodes refer to the event. There are some twenty-two distinct events categorized in LAMIS. Since the events depend on the type procurement the sequence obviously varies. The numbers above the arrows represent the standard times that have been established for completing that activity. The establishment of the tracking network and the activity times have been an evolutionary type of thing over the years. At first a committee comprised of management and experienced buyers arbitrarily established what activities and associated times were applicable to the particular type of procurement action. Since that initial effort, some networks have been added and others dropped. Those that remained, have been modified to accomodate the changes in procurement procedures. A statistical report is run on these networks each quarter which provides feedback to assess the validity of the standards. The networks are preprogrammed and exist in LAMIS as a table. Thus, when a buyer receives an authority to begin a contractual action, he selects the network applicable to the specific action and communicates this to the computer. This is done on a preformatted punch card transcript on which is placed the procurement identification number, the network code, and the start date of the network. LAMIS then communicates back to the individual by way of the "Buyer's Report" displaying the network and the scheduled dates on which each activity should be completed. From this point on, the buyers only input to LAMIS is the completion dates of the activities as they occur.

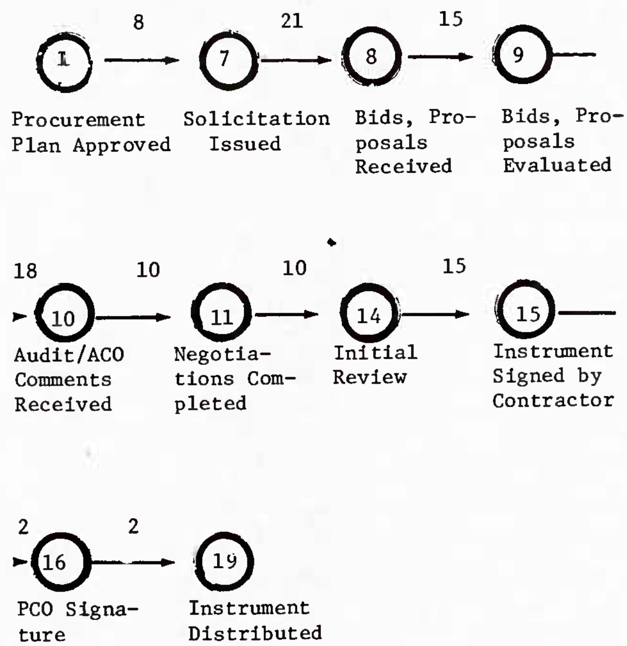

FIG. 1

LAMIS B1 NETWORK

(Total Workdays 101)

Workload Measurement. Another quite unique capability of LAMIS is the quantification of measurement of the procurement work load. In 1979, the Directorate sponsored a research project from the Air Force Institute of Technology on the subject of work load measurement. Using the results of this research, work point values were established for the activities of the tracking networks. By having these point values associated with the activities on these preprogrammed networks, LAMIS has the vehicle to assess and project the work load when a network is started and, also, to determine completed work load as completed dates are entered on the network. The work load, accomplished and projected, is provided to all levels of management on the "Management Report". This, of course, is available for each organizational element within the Directorate. From the management point of view, this capability has added a degree of flexibility to its task. This is especially valuable in the area of organizational assignments and has particular significance in managing a matrixed organization. Obviously extraordinary actions on any particular procurement are not accounted for with this system. However, management will usually be aware of this work load and accomodate it in the decision making process. The LAMIS work load measurement system has provided an invaluable tool for managing this procurement operation.

Future Plans. In order to keep any system viable, it is necessary that it change to accomodate the dynamic environment. Some very ambitious plans have been formulated for modernizing LAMIS. Currently, LAMIS is updated on a weekly basis both with pre and post contract data. The pre-contract data is provided by using the data accumulated by means of the AMIS and by field offices such as DCASR's. When the relocation of LAMIS is complete, it will be able to interface directly with the AMIS data base, precluding the requirement for weekly updating. It will also interface with the customer's management information system. This will provide LAMIS the data necessary to automatically project the PR numbers and dollars programmed for the next year.

With the automation of the contract writing function, it is planned that LAMIS will become a "real-time" system. In order to effect this the hardware and software must be compatible. Other things that are planned include transmitting data automatically via the contract writing equipment to the printing shop so that phototype setting for contractual documents can be accomplished without carrying a master copy to the print shop. Also planned is the automatic transmission of contractual data to the USAF's central collection points for statistical reporting. These are some of the ambitious objectives, but so was the LAMIS years ago.

Lessons Learned. In developing LAMIS, many things were learned that should benefit installation of similar systems in other contracting organizations. These lessons fall into three general categories. They are: Implementation, Input/Out, and Flexibility.

Implementation.

. The management of the organization must realize the need for the system. It must then aggressively direct and support the development and implementation of the MIS.

. The contracting organization must have sufficient data processing expertise in-house so that the organization's needs are uppermost during the design, development, and implementation of the MIS.

. Good working relationships must be cultivated and maintained between the contracting organization and the data processing organization to overcome the esoteric language barriers that exist between the two disciplines.

. The biggest hurdle to overcome in the implementation of an MIS is the resistance of the working level personnel to accept the fact that part of their job is to input accurate data into the system. This problem is eased by source data automation, or the collection of the data automatically as source documents are being prepared.

. Development and implementation is a time consuming effort. The implementation of an automated system is not an overnight project. Realistic schedules must be developed, understood, and accepted.

Output.

. Data input should be centralized as much as possible. Buyers should not be expected to become computer programmers or wrestle with computer type problems. Centralized operations personnel should handle all computer interaction other than the very routine.

. All individuals making data input should get feedback from the system. The shorter the time differential between input and feedback, the better.

. Recurring "hard copy" reports are preferred over CRT displays at all management levels.

. Use of the "management by exception" philosophy in hard copy reporting will preclude the organization from being inundated with paper. Nothing is more wasteful than generating reams of computer reports that are not needed or not understood.

. Summary type information must be available to supplement the exception reports to assess the work load pulse of the organization.

Flexibility.

. The technology of the word processing industry is advancing rapidly. The environment that impacts the contracting function is dynamic. Con-

sequently, an MIS that services the contracting function must be adaptable to change and yet maintain an overall stability.

. The MIS must be able to take on new data elements as the contracting environment changes and eliminate those that no longer serve the organization's needs.

. The output products also must reflect the needs of the organization. As the MIS matures, products will be deleted, added, and modified.

. Fewer data files provide faster interactive input/output capabilities. Therefore, the system should have a capability to purge the files periodically.

. A continuous program of education and public relations should be utilized to orientate new personnel to interact effectively with the system.

All of these lessons seem quite obvious on the surface. However, all too often, in the rush to get an MIS on-line, they escape consideration when decisions are being made.

SUMMARY.

To recap the capabilities of LAMIS, it is a very flexible system. The reporting, tracking, and data base are easily adaptable to any type of contracting. These include systems acquisition, base procurement, central procurement, and, of course, R&D Contracting.

LAMIS provides management visibility to every step of the acquisition cycle from the time of purchase request receipt through the final retirement of the contract. Being more than simply a PR tracking system, LAMIS is capable of tracking all areas of work load for the organization. The system also provides management a valuable tool by utilizing the "management by exception" principle. It reports on potential problem areas on a timely basis so they can be resolved rather than overwhelming management with volumes of data after a problem exists. The Directorate of R&D Contracting is fortunate to have such a working and effective management information system.

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TOTALLY INTEGRATED MANAGEMENT EVALUATION SYSTEM

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ABSTRACT

The intent of this paper is: to present a concept of analysis to be used in solving complex problems; to give better insight into cost relationships; to develop a better information system; and present a simple communication process for complex mathematical formulas. The ultimate goal is to furnish managers with a total cost relationship concept of analysis, which will lead to better decisions and a more effective use of our resources.

After many years of research, I have found that todays rapid computer processing of additions, divisions, and multiplications, open up a vast new world of analytical conceptions.

The key to this world is that all elements of cost must be related to an index of 1.000. This index can be quantified and tracked from the very lowest to the very highest level of review.

I hope you will share with me the excitement of finding this simple relationship such a valuable analytical tool.

INTRODUCTION

This paper reflects a continuing interest by the writer in the development of a better system for analyzing costs, with costs being referenced in the broad sense as value. This interest has led to numerous research projects in Industry and Government, and the implementation of evaluation systems, which have afforded valuable information and major improvements in management performance.

While numerous articles have been written relating to a totally integrated management information system, none to the knowledge of this writer have been formally presented.

The need for such a system is related in almost every management article you read with such titles as, "Management by Objectives," "Materials Management as a Profit Center," "Purchasing for Profits," "Who are your Motivated Workers?" and on and on.

They all relate in the simple sense to the fact that man should have a goal for improvement. These goals should be integrated with the goals of the organization in which the man functions in an optimum manner. As man and the organization act to reach these goals, by acquiring more and more information they make evaluations which are later determined to be right or wrong decisions. These decisions enhance or restrain the reaching or surpassing the established goals. In other words, the better the information received, the better decision man is able to make and the more rapidly he will reach his and the organization's goal.

When recognizing that most of man's time is spent in making decisions, either moral or material, which may be right or wrong, depending on the information received, there should be no doubt that man should never stop improving his information system.

While in the broad sense, an information system is infinite relating to all mediums of communication which culminate in man's mind, this paper relates primarily to the systematic flow of information within an organization in a continuing timely manner in order that managers at all levels can make better decisions.

PRIMARY CONSIDERATIONS

The key to company strategy on decision making is a good information system which affords necessary evaluation information of a high quality in a prompt manner. This information system must give proper balance to all key elements of cost, at a low cost for accumulation, retention, and dissemination. In order to provide this proper balance objective, the information must be presented with a common denominator. The concept used in this report is the fact that all cost references must be related to the value 1.000.

ONE-THE FOUNDATION OF TOMORROW'S ANALYTICAL SYSTEM

The concept presented in this chapter is that the most demanding cost analysis review, with infinite cost variables, and infinite complexity, can be simply analyzed and more important communicated with the use of a simple concept.

The fundamentals involved in this concept is that the number 1.000 must be recognized as the basis of comparison at all levels of review. The only analytical abilities required are an ability to add, divide and multiply. The concept presented is ideal for computer application, and is expected to revoluationize the computer information system.

In presenting this concept it might be noted that although one thousand, one million, or one billion might be used, that these figures are still considered one. The added zeros are only presented to give mangnitude for better communication with the reader.

It is the purpose of this chapter to emphasize the value of relating all costs to the standard of one. The standard of one can be related on a composition basis, which evaluates each element of cost or price, referred to as a vertical review, or it can be related on a time basis, where each element of cost or price is related to the change which takes place over a specified period of time. The base period for comparison is referred to as one. The Producers Price Index may be recognized as this type of application, and is considered a horizontal/time review.

The following illustrations each relate to specific studies which have been performed since 1954.

The resulting conclusion is that all comparative analysis reviews, at every level of review, must be related as a positive or negative variance from one, from the very lowest level of review to the very highest, if an exact comparison is to be achieved at the highest level.

Whether analyzing a one hudred billion dollar Federal budget, the profit or loss of a major corporation, or your own family budget, the basic concepts are the same. We are constantly analyzing the composition of these costs, within the framework of past costs, current costs, and future projected costs. The concept 1.000 remains the standard of reference in every instance.

The following illustrations, followed by comments, are presented to detail the empirical studies which were performed to support the concept that 1.000 is the foundation of all of tomorrow's analytical systems:

Table 1. Analysis of Sales Dollar Distribution for the Years 1975, 1976, 1977

	1975 profit and loss statement	1975 \$ volume per \$1,000 sales	1976 \$ volume per \$1,000 sales	1977 \$ volume per \$1,000 sales
Material	\$2,550,174	\$678.96	\$662.05	\$644.44
Less Scrap Value	-75,120	-20.00	-22.73	-21.95
Net Material Cost	\$2,475,054	\$658.96	\$639.32	\$622.49
Variable Burden	258,638	68.86	72.92	81.34
Fix Burden	375,562	99.99	105.76	113.05
Total Cost	\$3,109,254	\$827.81	\$818.00	\$816.88
Profit	646,746	172.19	182.00	183.12
Total Sales	\$3,756,000	\$1,000.00	\$1,000.00	\$1,000.00

Table 2. Analysis of Material Cost Distribution

	1975 profit and loss statement	1975 \$ volume per \$1,000 sales	1976 \$ volume per \$1,000 sales	1977 \$ volume per \$1,000 sales
Roll Stock	\$2,334,842	\$621.63	\$614.66	\$600.52
Scrap Net	-75,120	-20.00	-22.73	-21.95
Net Material Cost	\$2,259,722	\$601.63	\$591.93	\$578.57
Sheets	2,742	.73	.19	1.36
Adhesives	80,115	21.33	18.55	19.14
Tape	37,410	9.96	7.69	10.70
Wire	8,038	2.14	1.84	1.48
Twine	6,432	1.71	1.23	1.32
Ink	19,043	5.07	7.90	6.86
Staples	751	.20	.24	.20
Paraffin	2,254	.60	.49	1.07
Other Prod. Mat.	60,096	16.00	8.48	1.79
Finished Goods	1,991	.53	.98	----
Total	\$2,550,174	\$678.96	\$662.05	\$644.44
Scrap Return	-75,120	-20.00	-22.73	-21.95
Net Material Cost	\$2,475,054	\$658.96	\$639.32	\$622.49

ANALYSIS OF SALES DOLLAR DISTRIBUTION

The subject presentation uses $1,000 in lieu of 1.000 to give better perspective. The common denominator is basically one. The first column of numbers "The Profit and Loss Statement" is presented to illustrate the raw material for the 1975 "$Volume per $1,000 sales". Similar information was also used for 1976 and 1977. The information which is developed is computed by dividing the dollars expended in the cost element into the total sales dollar for each year. The importance of this function is that all cost elements must have a common denominator for equal comparison.

The more detailed presentation shows the ability to detail cost trends for costs of only pennies relative to $1,000 in sales.

Table 3. Important Concepts of Cost Accumulation

Example of Computer Evaluation.

FY 1972 P/N ABC

Qty.	U.P.	Total
10 ea	$5.00	$ 50.00
10 ea	$5.00	$ 50.00
20 ea		$100.00
Avg. Unit Price		$5.00

FY 1973 P/N ABC

Qty.	U.P.	Total
5 ea	$6.00	$ 30.00
5 ea	$6.00	$ 30.00
5 ea	$6.00	$ 30.00
5 ea	$6.00	$ 30.00
20 ea		$120.00
Avg. Unit Price		$6.00

Variation Analysis

$\frac{6.00}{5.00} = + 120\%$

Conclusion: 1972 1.000 1973 1.200

FY1972 P/N XYZ

Qty.	U.P.	Total
25 ea	$10.00	$250.00
5 ea	25.00	125.00
10 ea	20.00	200.00
10 ea	20.00	200.00
50 ea		$775.00
Avg. Unit Price		$15.40

FY 1973 P/N XYZ

Qty.	U.P.	Total
5 ea	$25.00	$125.00
5 ea	25.00	125.00
10 ea	20.00	200.00
10 ea	20.00	200.00
10 ea	20.00	200.00
40 ea		$850.00
Avg. Unit Price		$21.24

Variation Analysis

$\frac{21.24}{15.50} = + 137.096\%$

Conclusion: 1972 1.000 1973 1.371

Composite Review of Items ABC and XYZ.

P/N ABC	20 each 1.00	20.00	20 each 1.20	24.00
P/N XYZ	40 each 1.00	40.00	40 each 1.37	54.80
		60.00		78.80

$\frac{78.80}{60.00} = + 131.34\%$

Conclusion: 1972 1.0000 1973 1.3141

IMPORTANT BASIC CONCEPTS OF COST ACCULUMATIONS

The subject presentation details important programming concepts which must be followed to relate all procurements in one period 1973 relative to another period 1972, on a one relationship basis.

It should be noted mathematical computations of addition and division are required to develop a relationship of 1.000 to 1.200 for item ABC and 1.0000 to 1.3134 for item XYZ.

It should be further noted that a quantitive weighting relationship is developed for each item reviewed as well as the combination of two items, which reflects a price relationship for the six procurements in 1972 relative to the nine procurements in 1973 of 1.000 to 1.310. In other words, the average price paid for the two items in 1973 was $1.31 for each $1.00 which was expended in 1972. This same cumulative relationship can be applied to millions of procurements, with the communication of an exact cumulative cost/price relationship.

The comparative analysis can be related by specific item, by item groups or classes, by buyer, by vendor, or any other category which might be conceived. The end results are always a relationship to 1.000.

The cumulative dollar amount within the category evaluated is then applied to the factor. For example, if the index for vendor A, in 1973 was .98 and $980,000 was purchased from the vendor in 1973, the evaluation process would be telling management the quantity of material purchased in 1973 at $980,000 would have cost $1,000,000 if purchased in 1972, or if buyer A's index for 1973 was 1.340 versus 1.000 in the base year 1972, it would be telling management that for each million dollars buyer A spent on a 1972 cost basis, he was now spending $340,000 more. Management in accumulating these indexes for 100 or 1,000 buyers, if finding that a cumulative index of 1.01 is developed in a $200,000,000 procurement environment, would be realizing that additional cost expenditures attributed to material cost/price escalation was $2,000,000 more in 1973 than in 1972. In a sense this is similar to a "Producers Price Index" except that instead of being related by statistical sampling, every single procurement would have been evaluated. While realizing that millions of computations (additions, divisions, and multiplications) would be involved. This is a simple task in a computer age.

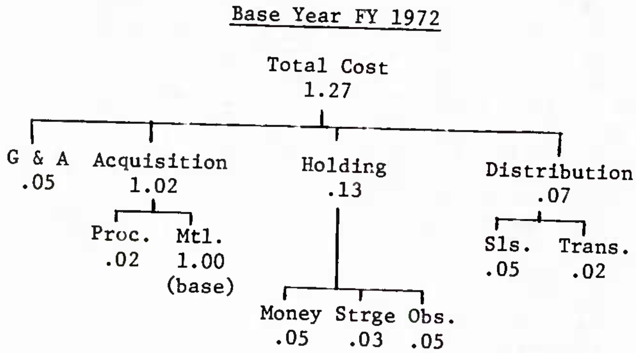
TOTALLY INTEGRATED EVALUATION SYSTEM

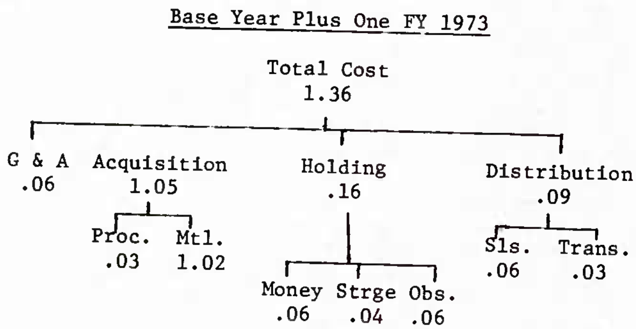
The model illustrated on the following page, reflects a composition of all costs in an exact relationship relative to 1.000. The base year model reflects the fact that the base for continued cost projection is the material dollar. This base 1.000 might well have been the total cost 1.000, in lieu of the material 1.000, depending on the analysis required.

Total costs can be evaluated on either a composition or time basis. Each cost fraction or total cost reflects an exact fraction relationship to the total material dollar expended. Example: If 300,000,000 in material was purchased in base year at 1.000 and .13 was holding cost,

the holding cost is $39,000,000. (.13 X $3000,000,000). Total break even cost were $381,000,000 (1.27 X $3000,000,000).

Table 4. Totally Intergrated Evaluation System





Definitions:

G & A - - -General and Administrative Costs
Proc. - - -Procurement Operating Costs
Mtl.- - - -Direct Material Purchasing Cost
Money - - -Cost of Money tied up in Inventory
Strge.- - -Warehouse Operation Cost
Obs.- - - -Net Cost of Obsolete
Sls.- - - -Total Cost of Sales
Trans.- - -Transportation Cost

COST ANALYSIS REVIEWS ON GOVERNMENT CONTRACTS

In evaluating firm fixed price proposals on repeat Government procurements, the application of the unit 1.000 variance concept of analysis has been applied with interesting results, and valuable research experience is expected.

The two concepts applied to procurements which extend back to 1976 are described as a horizontal/time analysis review, and a vertical/composition analysis review.

The horizontal review shown at the top of Table 6 reflects a comparative analysis of the cost shown on Table 5 as proposed and recommended. The relationship comparison is to the time of the first review that has been documented. Both proposed and recommended columns are added each time a new review is performed.

The vertical/composition review at the bottom of the Table reflects a comparison of cost elements relative to total price proposed, and the cost elements relative to the total price recommended.

It should be noted in reviewing Table 6 horizontal time analysis, that each element of cost can be analyzed from proposal/recommendation to the next proposal/recommendation, or to the most current proposed/recommended. Needless to say substantial inquiry can be made during negotiations with the contractor. And it is not infrequent that the contractor is unable to support unusual positive variances.

In a similar manner the vertical/composition analysis can be used to propose inquiry regarding substantial changes in the material, labor, or overhead costs.

Referring back to the totally integrated evaluation system, if the subject analysis results in a .01 material cost reduction on $100,000,000 in annual procurements, a savings of $1,000,000 will result.

Table 5. Review of Proposed and Recommended Costs

A B C Company

Cost Element	Prop. Oct 76	Recom. Dec 76	Prop. May 79	Recom. Oct 79
Purchased Parts	166.30	166.30	229.96	207.31
Raw Material	2.06	2.05	3.24	3.24
Material Overhead	24.41	24.41	46.17	16.42
Sub Total	192.77	192.77	279.37	226.97
Material Additive	13.30	13.30	120.97	19.07
Conversion (DL&OH)	21.61	21.66	49.79	48.42
Conversion Additive	9.10	9.10	1.94	.39
Total Mfg. Cost.	236.82	236.82	452.06	294.84
G. and A.	46.65	44.76	81.37	25.95
Total Cost	283.47	281.58	533.43	320.79
Cost of Money	-0-	-0-	2.94	2.61
Profit	42.52	28.47	80.02	34.87
Price Proposed	325.99	310.05	616.39	358.17

Table 6. Index of Proposed and Recommended Costs

Cost Element	Prop. Oct 76	Recom. Dec 76	Prop. May 79	Recom. Oct 79
Horizontal/Time				
Purchased Parts	1.000	1.000	1.382	1.246
Raw Material	1.000	1.000	1.572	1.580
Material Overhead	1.000	1.000	1.891	.672
Sub Total	1.000	1.000	1.449	1.177
Material Additive	1.000	1.000	9.095	1.433
Conversion (DL&OH)	1.000	1.000	2.298	2.235
Conversion Additve	1.000	1.000	.213	.042
Total Mfg. Cost	1.000	1.000	1.908	1.245
G. and A.	1.000	1.000	1.744	.579
Total Cost	1.000	1.000	1.881	1.139
Cost of Money	-0-	-0-	2.145	2.122
Profit	1.000	1.000	1.881	1.224
Price Proposed	1.000	1.000	1.890	1.155

(Table 6. continued on Page 5)

Cost Element	Prop. Oct 76	Recom. Dec 76	Prop. May 79	Recom. Oct 79
Vertical/Composition				
Purchased Parts	.5101	.5364	.3731	.5794
Raw Material	.0063	.0066	.0053	.0090
Material Overhead	.0749	.0787	.0749	.0453
Sub Total	.5913	.6217	.4532	.6337
Material Additive	.0408	.0429	.1963	.0532
Conversion (DL&OH)	.0664	.0699	.0808	.1352
Conversion Additive	.0279	.0294	.0031	.0011
Total Mfg. Cost	.7265	.7638	.7334	.8232
G. and A.	.1431	.1444	.1320	.0725
Total Cost	.8696	.9082	.8654	.8957
Cost of Money	-0-	-0-	.0048	.0073
Profit	.1304	.0918	.1298	.0974
Price Proposed	1.0000	1.0000	1.0000	1.0000

DL&OH- - -Direct Labor and Overhead

MAJOR COST REDUCTION POTENTIAL

Problem. Management is confronted with a decision of cost versus savings in buying 25 each of an item at $249.28 each or 50 each at $163.78 each. What are the costs and savings involved.

Solution. Detail total costs involved under each environment by major category such as purchase material cost; ordering cost; holding cost. Example:

Cost Element	Cost Per Unit Decision A	Cost Per Unit Decision B
Purchased Material Cost	$249.28	$163.78
Cost to Order	4.00	2.00
Cost to Hold Material	7.79	10.24
Total Cost	$261.07	$176.02
Net Reduction		85.05

Analytical Review	Cost Per Unit Decision A	Cost Per Unit Decision B
Purchased Material Cost	1.0000	.6570
Cost to Order	.0160	.0080
Cost to Hold Material	.0312	.0411
Total Cost	1.0472	.7061
Net Reduction		.3411

Evaluation. In the subject review the final presentation to management is the fact that because of applying Decision B, a total procurement value of $8,801 ($176.02 X 50), is advisable, a cost reduction of .3411 was recognized. This took into consideration holding and ordering cost, as well as material cost. The decision process, through a better analytical review, resulted in a savings of $4,252.00 (.3411 X 50 X $249.28).

Communication. In the above presentation emphasis is given to the fact that composition costs for holding and ordering can be related on a descending basis as well as cost reductions or savings accumulated further on an ascending basis. It has been contended that the above decision change will result in an approximate $15,000,000 reduction in a $300,000,000 annual procurement environment. In the totally integrated evaluation system model this is recognized as a change from 1.000 to .9500.

SUMMARY

The fundamental concepts presented in this paper are to emphasize the following concepts:

Management effectiveness is no greater than the effectiveness of the manager at each and every level of review below him, down to the man performing on the job, who is managing his own mental and physical resources-the man who is actually achieving the goals of every higher manager. The goals of the higher manager are therefore of extreme importance and extend from the top managers of our Country, to the manager of mental and physical resources at the operating level.

Because of the extreme importance of the decisions of every manager, it is equally important that every manager receive an accurate and rapid reply to his decision process.

A totally integrated management evaluation system can assure every manager that he is: (1) looking at all the costs within his operation, not just a few which can result in serious adverse management decisions. (2) the "Relation to One" concept of analysis emphasizes that we must review 100% of all costs within our sphere of management, and we must transmit the effect of this 100% review as a quantified positive or negative result to every higher level of review.

To be accurately compared or analyzed we must relate all costs on a relationship to 1.000 (100%) basis.

The computer age, coupled with the "Relation to One", concept of analysis offers fantastic possibilities for accurately and rapidly transmitting the millions of positive and negative variables needed to make a totally integrated management evaluation decision, and as a result, better use of the most important resource of all-man himself.

An overview of this concept of extension to the highest levels of review is detailed below:

Table 7. Descending Base Focus Analysis Concept

Focus Point	Focus Base	$ Budget	One	Two
GNP	1	3 Trillion	1.000	
Fed. Gov't	2	600 Billion	.200	1.000
Dept. of Def.	3	150 Billion	.050	.250

GNP- - -Gross National Product

INCREASING PRODUCTIVITY IN PROCUREMENT THROUGH THE USE OF AUTOMATION

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ABSTRACT

Headquarters, DARCOM, Procurement and Production Directorate, designed an ADP system to automate procurement processes. It is called the Procurement Automated Data and Document System (PADDS). Its concept is innovative and a major accomplishment in automating procurement operations. PADDS' development utilizes an evolutionary arrangement of a growing array of information processing capabilities. At times we were in a pure research and development phase. We combined new hardware and software technologies in an interactive mode, considering human engineering requirements, for the best possible procurement operating system designed within the current state-of-the-art. PADDS utilizes a computerized data base in a distributive processing mode, producing documents such as solicitations, contractual documents, modifications to these documents, including procurement and production management reports. The functions just mentioned are performed automatically under PADDS. The most significant advantage of PADDS is that it provides contract standardization. A cost benefit analysis indicates a $37.5M savings for DARCOM over the next eight years. The dollar savings does not include a 5% increase in anticipated procurement productivity in awarding contractual instruments.

BACKGROUND

Complex economic and technical changes have combined to make the procurement of equipment and material supporting a modern peace time army more challenging. This paper provides an overview in solving one problem challenging DARCOM's procurement community. It is the automation of the procurement processes through integration of word processing, computer systems and minicomputer technology for installation and use at DARCOM's Major Subordinate Readiness Commands. The ADP system is called the Procurement Automated Data and Document System (PADDS). It represents the first operational application of many planned standard applications of the distributive functional processing concept.

Resource Trends. Since the height of the Vietnam build up in 1968, the total DARCOM authorized strength has dropped from 183,000 to 112,000 in 1980. During this same time, the complexity of procurement and other factors reflecting increase in workload effort to procurements, such as increased implementation of socio-economic programs, increase in FMS program, and new missions, have created an unprecedented high demand for manpower in the procurement community. These factors ultimately translated into large numbers of procurement actions to be processed, an unacceptable procurement backlog, and an increasing procurement administrative lead time. All of these factors contributed to increased cost and seriously hindered efforts to obligate procurement programs against the plan, and seriously jeopardizes the Army readiness posture. Other functions were also being adversely impacted. For instance, we are unable to perform adequate procurement planning. In the contract administration are, contract close-out function was deferred. This means funds are tied up that could not be deobligated and reprogrammed to satisfy other requirements.

GENERAL OBJECTIVES

In considering the concept for PADDS, special attention was given to objectives which had already been established for ADP systems in general, for logistics systems, and for a specific procurement system to meet DARCOM's needs. The distributive functional processing concept was selected. The procurement system undertaking was determined to be a large-scale multi-functional, standard, integrated, automated system with significant telecommunications requirements.

Recommended Objectives. 1. The PADDS should be cost effective and justified on the basis of demonstrating this effectiveness through an economic analysis and other appropriate actions.

2. In procurement, contract administration, and with DARCOM's host computer, interface capabilities must be provided, where an interchange of information is required, considering the following:

a. Standard data elements, formats, and procedures for contractual instruments.

b. The flow of data among PADDS and the host computer should be maximized.

c. PADDS shall use source data automation and source document preparation in all contractual instruments.

3. PADDS will be developed on a modular phased approach to the design and implementation of large-scale, multi-functional, integrated system to facilitate responsiveness and change.

THE PADDS SYSTEM

PADDS utilizes a computerized data base that is designed to streamline and standardize DARCOM's contracting functions. The system uses terminals and a dedicated mini-computer in a distributive processing mode producing documents such as solicitations, contractual documents, modifications to these documents, DD Form 350, procurement and production management reports, and transactions for updating files in DARCOM's Commodity Command Standard System (CCSS). PADDS, uses to a large extent, source information previously recorded in CCSS files in automating solicitations and contract documents, including changes and required reports.

Automated Responsiveness. The referred to above functions are performed automatically under PADDS. PADDS provides quick access and rapid output of contract information. The system replaces manual and semi-automated procurement processes with almost total automation. And as a by-product of the PADDS system, MILSCAP transactions are automatically generated and dispatched for use in performing contract administration functions by DCAS.

Solicitation Process. In this process a buyer receives a procurement work directive and annotates on a transcript sheet data needed for preparation of a solicitation. This data is than input at the terminal. Computer input, by purchase request number, automatically starts to produce a solicitation, consolidates PRs on the solicitation using information previously recorded in the CCSS or PADDS files. For example, when the PR number is entered into the terminal stored information, such as stock number, description, and packing and shipping information, is automatically printed in the appropriate blocks or schedule on the solicitation document. At the same time, a bidder's mailing list tailored to the specific solicitation is produced by the standard automated bidder's list system. As a matter of information, any data can be changed prior to recording the issuing of the solicitation. When the solicitation has been issued, any changes to it can be made by an amendment. These solicitation amendments can be automatically produced by the PADDS system.

Contract Awards. The information applicable to the solicitation process is held in the recycle and suspense file in the PADDS computer. The PADDS system has the capability to recycle the data to automatically produce a contract. All the terminal operator has to do is insert a small amount of variable information such as the successful bidders code, unit price, and the computer will automatically prepare a contract ready for signature and distribution.

Legal Review. PADDS reduces legal review time for contract actions. Today in the manual environment each award document must obtain a review by a board and legal personnel. Based on type of contract, dollar threshold, and other determining factors, the clauses and appropriate narrative are thoroughly reviewed. Under PADDS, based on the same criteria, the appropriate clauses and narrative are initially reviewed and approved before such clauses are placed in the regulation reference file of the computer. PADDS automatically extracts clauses from the computer and prints them on the award document. Now when additional clauses or narrative are added or standard requirements have been deleted in "tailoring" a specific award, the PADDS system will automatically produce an errata sheet citing the specific area which was added, changed, or deleted. When this happens, the document will receive detailed legal review. In addition, PADDS provides direct access and inquiry capability to the legal office through use of their own terminal.

Management Reports. Through the procurement management and reports cycle, PADDS produces important documents such as the DD Form 350, the Individual Procurement Action Report as an automatic by-product of contract awards and modifications. It also produces other reports and registers applicable to the various procurement processes.

Economic Impact. PADDS will not cause a reduction in employees. Rather PADDS will allow a contract specialist to devote more time to negotiation and monitorship which tasks are very important to the procurement process. Better use of time is a benefit that applies also to clerks and typists who in the past prepared manual awards and who manually abstracted information for MILSCAP transactions (reference data discussed in the "background" portion of this paper). As far as money is concerned, DARCOM's cost-benefit analysis resulted in a $37.5M cost benefit over an eight year period. These stated savings do not include an estimated 5% increase in buyer productivity of contractual instruments.

PADDS Operating System. To appreciate the magnitude and complexity involved in the development, design and programming of PADDS, the following structure represents the operating system:

PADDS is a mini-computer system accepting data input via interactive terminal programming utilizing a transaction processor, data base management system, and powerful text processor software package. All standard procurement forms and legal documents are dynamically generated and printed on a variable font and size matrix printer. The system is comprized of seven major application processes (287 COBOL programs), supported by seven standard operating instruc-

tions, one terminal operating instruction and four functional operating instructions.

CONCLUSION

In the development of PADDS, DARCOM analyzed the tools and the technology available, decided on the thrust in distributed process as best satisfying procurement requirements, making the workforce more productive, and to improve our mission support. Payoffs are expected in terms of improved performance, improved personnel motivation, reduction in effort requirements, improved accuracy and standardization of procurement instruments, and overall reductions in completion times for contractual actions.

REPORTING FEDERAL PROCUREMENT ACTIVITY: A REVIEW OF THE FEDERAL PROCUREMENT DATA SYSTEM

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ABSTRACT

The proliferation and duplication of reports now required of Federal procurement offices make it more difficult than ever to accomplish the basic job of acquiring goods and services. While many Federal agencies realize the need to automate procurement document preparation, few have proposed to eliminate all manually compiled reports through this procedure.

The Federal Procurement Data System (FPDS), mandated by the Office of Federal Procurement Policy (OFPP) Act of 1974, can provide a central repository for procurement information and thus rid procurement offices of burdensome reporting. To do so, however, FPDS must correct major flaws and misleading data representations, and provide more complete information than it is now designed to do. OFPP and the agencies must take a more serious approach toward using FPDS to satisfy reporting needs. OFPP must provide stronger policy direction to insure complete, accurate and timely data submission, and exercise its authority to stop the proliferation of reporting requirements upon our Federal procurement offices. Each agency must devote adequate resources to insure that information concerning its procurement activity is accurately portrayed by the FPDS.

INTRODUCTION

Several agencies already have or are planning systems to automate at least some portion of the procurement process. However, most of these systems are geared toward tackling what I term the "front end" of the procurement process. That is, they focus upon various pre-award phases up to or including a final contract document. This paper deals with an increasingly important post-award consideration -- that of reporting procurement information and related statistics.

With each passing day, procurement offices are required to provide an ever-increasing amount of procurement information. Reports, despite many previous efforts to foster change, continue to be the bane of existence for Federal procurement offices. Reports do not help the procurement professional get his job done, nor do they assist him in doing that job better.

Invariably, when a shoddy or questionable contracting practice is uncovered, or a new socio-economic program is enacted, it means that an additional control -- and a report -- are required of each procurement office. We have reached the saturation point. That is, the demand for information upon Federal procurement activities has far outstripped the ability of the Federal Government to provide it with the degree of completeness, accuracy, and timeliness required. Simply stated, we do not know how much and with whom the Federal establishment spends in procuring its goods and services.

Despite the advances in modern technology, the average procurement office is still doing business as it did in 1790. To be sure, that office is now blessed with some modern "conveniences" such as electricity, telephones, and typewriters. In return, however, our procurement employees must tolerate the glut of regulations, restrictions, prohibitions and, of course, reports which go with the job. As a whole, the Federal procurement community has yet to make across-the-board advances in linking 21st-century technology to 18th-century clerical functions, and the ability to report our procurement activity in a modern, usable, consistent fashion.

OBTAINING PROCUREMENT STATISTICS

In its final report, the Commission on Government Procurement (COGP) noted that each agency attempts to collect procurement data in whatever way might be useful for internal management and for submitting reports to other organizations, such as the Office of Management and Budget (OMB) and Congress. The range of published data for each agency ranged from extensive to little or none at all. This lack of consistency stemmed from the fact that no single Federal organization was responsible for collecting and reporting information on Federal procurement activity. COGP Recommendation D-1 stated:

> "Improve the system for collection and dissemination of statistics on procurement by commodity and agency to meet Congressional, executive branch, and agency needs."[1:5]

Congress also recognized the potential benefits of such an operation, and incorporated Recommendation D-1 into what became Public Law 93-400, "The Office of Federal Procurement Policy (OFPP) Act of 1974."

Specifically, Section 6(d)(5) mandated the establishment of a system for "collecting, developing, and disseminating procurement data which takes into account the needs of Congress, the executive branch and the private sector."

Upon enactment of Public Law 93-400, a task group was organized to assemble the framework of such a system. The group, comprised of members from the larger Federal departments and agencies, met under supervision of the Office of Procurement Management, then a part of the General Services Administration's (GSA) Office of Federal Management Policy. This organization was transferred to OFPP in early 1976, and that Office assumed supervision of the task group.

The task group met regularly for over three years, deliberating and considering suggestions on the nature and type of data to be collected, and the means used to code and portray the information. Start-up funds were needed, as was an organization to act as Executive Agent for the newly-named Federal Procurement Data System (FPDS).

The years of effort culminated on February 3, 1978, with the issuance of a memorandum from the OFPP Administrator. The memorandum established a Federal Procurement Data Center (FPDC), and transmitted the initial reporting instructions and manual. Data collection was to begin on October 1, 1978, the beginning of Fiscal Year 1979, with reporting to FPDC on a quarterly basis. The Department of Defense (DOD) was designated Executive Agent for FPDS, and a FPDS Policy Advisory Board and system of operations contact points were established. [2]

OPERATION OF THE FPDS

The FPDS began collecting data for Fiscal Year 1979. Transactions are reported to FPDS in two fashions on the basis of dollar value. Procurement actions of $10,000 or less are reported in summary form on a quarterly basis using Standard Form (SF) 281, "FPDS - Quarterly Summary of Contract Actions of $10,000 or Less and Subcontract Data on Selected Prime Contracts." Actions valued at over $10,000 are reported individually, by quarter, on a more detailed report, SF 279, "Individual Contract Action Report." The current SF 279 collects information in 27 different areas. In addition, a number of one-time reports were required of each agency, such as lists and codes for its procurement offices and a master list of its present and past contractors. Agencies were also required to adopt the Dun and Bradstreet Universal Numbering System (DUNS) as a means of contractor identification [3:5-6]

The FPDC has been in existence for over two years, and a review of its positive and negative aspects is in order. This examination is geared toward answering two questions: (1) How well does the FPDS satisfy the need for procurement information? and (2) How can the establishment of FPDS help reduce the number of reports presently required of Federal procurement offices?

The FPDS has collected data for just one year. As in any new system, there are growing pains, both in the FPDC itself and in the agencies which report to it. Each agency can probably produce a long list of complaints about FPDS and the fact that it represents yet another set of reports to prepare. A discussion of those relatively insignificant problems would overlook the important areas of my concern -- the areas upon which the ultimate success or failure of FPDS will depend. As an active participant in both the creation and current operation of FPDS, I see seven major obstacles to the success of the System.

1. <u>FPDS is based upon the DOD system</u>. Because DOD supplied the positions and initial funding, the other agencies were forced into a system which, while easy for DOD to implement, was difficult for those with more modern, automated means of data gathering. The DOD system of obtaining procurement data from its DD 350 forms ("Individual Procurement Action Report") is over 15 years old. OFPP was willing to live with several flaws in the DOD reporting system, not because it was the best available, but because it was the quickest and easiest way of securing DOD input to FPDS. The three major flaws are discussed in points 2, 3, and 4 below.

2. <u>The FPDS does not show contract expenditures by quarter</u>. Although agencies are required to report quarterly, the actual award date is secondary to the quarter in which the action is reported. [4:5] Therefore, there is no correlation whatsoever between contract expenditures and FPDS reports. This feature of FPDS is not mentioned in any of the reports it produces, nor are those who request information from FPDC ever apprised of this fact. Showing actions only in the quarter reported will produce a large bulge of actions and dollars in the last quarter of a fiscal year, as rejected actions from the three previous quarters will be corrected and resubmitted at the end of the year. There is enough concern about last quarter spending without this sort of misrepresentation of the facts.

3. <u>The FPDS is a transaction-based system</u>. Only actions with a value of more than $10,000 are reported individually. [4:5] Therefore, the actions on any contract in FPDS may be incomplete, since modifications of $10,000 or less need be reported only on the quarterly summary. Contracts which contain frequent small value modifications -- prime candidates for closer scrutiny -- will never be uncovered if investigators rely on the FPDS, a system which is supposedly our single Federal organization for collecting and reporting information on Federal procurement activity.

4. <u>Coding individual FPDS transactions is burdensome</u>. The contract specialist preparing SF 279 is greeted with an unwieldy set of coding choices, many of which are subject to interpretation or cannot be coded from the information available in the contract file. For example, there are almost 2,000 codes for the products or services being procured [5], and the list

is still growing. Is that much detail necessary for all agencies because DOD desires it?

5. Too many transactions have been rejected from FPDS because of improper edit specifications. The FPDS is supposed to portray procurement activity, not set procurement policy. Some of the edit specifications reject actions which are perfectly acceptable procurement policy and procedure. Such problems could have been avoided if OFPP, as the final authority on procurement policy, had carefully reviewed the FPDS edit specifications when they were issued in August, 1979. OFPP could then have ordered them corrected or modified. In addition, there were inconsistencies between FPDS reporting instructions for certain types of procurement and the FPDS edits which are applied to those actions when submitted.

6. FPDS must avoid becoming political. Everyone wants to be able to obtain data on his pet program instantly. However, supplying minutiae on each procurement places an undue burden on those who award the contracts and complete SF 279. FPDS needed a forum to examine specific data needs which would have an impact on the current System. The FPDS Task Force on Improvement became such a forum. The Improvement Task Force, comprised of members from both large and small agencies reporting to FPDS, is responsible for reviewing proposed changes to FPDS and recommending a course of action or disposition to the FPDS Policy Advisory Board. The Task Force foresaw the potential of turning FPDS into a bloated, cumbersome monster by requesting too much information from already overtaxed procurement offices, especially data needed only by select influential persons or special interest groups. The Task Force at the outset established the following criteria for reviewing proposed changes to the FPDS:

   a. Changes must be of benefit to more than one agency or part thereof, with due consideration given to the procurement volume of each agency;

   b. Information must be readily available for coding based upon material in a reasonably complete contract file;

   c. Codes to be used must be clear, not subject to significant interpretation, and not requiring an additional person (a subject expert) to complete the coding;

   d. A data field must be for a current broad-based need, and not a substitute for review of individual contract files. The data should not be collected in anticipation of a non-specific future request;

   e. Any change should be easily incorporated into the existing FPDS structure;

   f. Any change should not be overly burdensome nor require significant additional manhours to complete in relation to the value or benefit of the information provided.

   g. Any change should be reasonably compatible with existing agency procedures. [6:3]

7. The difficulties of implementing FPDS were underestimated. OFPP and the agencies did not realize the full impact of FPDS upon the operation of the average procurement office. OFPP did not adequately assess the costs and burden to implement FPDS within the agencies, even those with established data collection systems. Developing new or revising existing collection procedures, converting computer programs, and training personnel all have taken time and money. Agencies have likewise taken the task of implementation lightly by not devoting sufficient funds and resources to prepare for the FPDS requirement.

THE FUTURE OF FPDS

FPDS can work. It can become the focal point for Federal procurement information and eliminate the duplicative, time-consuming requests for data which a procurement office invariably receives late on Friday afternoons.

Significant changes are necessary if FPDS is going to assume the role intended for it. These changes include the following:

1. FPDS must evolve away from the DOD format. The recent transfer to GSA of executive agency for the System should help in this regard, but that remains to be seen.

2. Change the reporting format to show quarter obligated, not quarter reported. FPDS is updated with each quarterly submission, and supplemental or resubmitted data are accepted between reporting dates. It is only fitting that FPDS provide the most accurate information it can at the time a report is prepared. Everyone who requests information is entitled to receive it according to this philosophy, and it is naive and foolish to think that anything less is acceptable.

3. Report all transactions on formal contracts. Do not restrict submissions on SF 279 to actions over $10,000. Once a contract is in FPDS, track all monetary actions on it regardless of dollar value.

4. Keep politics out of FPDS. Maintain the Improvement Task Force concept to review changes for approval of the Policy Advisory Board. FPDC must not attempt to override this process because of political expediency or undue outside influence. OFPP should likewise not try to override decisions of the Policy Advisory Board or circumvent the process.

5. Strengthen FPDC contact with the individual agencies. Almost no one on the FPDC staff has had operational procurement experience. Such expertise is essential in communicating effectively with the agencies' points of contact, who are generally persons with a procurement background. The FPDC staff needs to be augmented in this regard. Each agency now deals with a FPDC action officer who usually works with more than one agency reporting to FPDS. Each action officer should be thoroughly familiar with the way agencies under his cognizance submit data to FPDC. For example, is the submission by hard copy, punch cards, or computer tape? Is the agency gathering data solely for satisfying FPDS requirements, or is FPDS data a by-product of an agency's internal information system(s)? The action officers should be in a position to offer advice and assistance in resolving any problems of an agency in submitting data to FPDC.

6. OFPP must convey its message about FPDS more forcefully. Unfortunately, OFPP has not been serious enough about making FPDS work. Too little correspondence and policy on FPDS is being published by OFPP. Policy direction must not be permitted to be issued by FPDC. OFPP, through OMB, has the influence, but it must use it to emphasize, on a continuing basis, the importance of FPDS. One way would be to inform agencies that FPDS data will be used to gauge the effectiveness of procurement-related programs such as disadvantaged and women-owned business initiatives and Labor Surplus Area set-asides. FPDS should become the only source for obtaining such information. OFPP must also impress upon officials, at the highest level in each agency, that their support -- with funds and personnel -- is vital for FPDS. Finally, OFPP should also provide the initiative for supplying complete, accurate and timely data by indicating those manually compiled reports which will be eliminated when FPDS reaches the necessary level of accuracy.

CONCLUSION

FPDS can be of great value if it accurately portrays procurement activity and eliminates other reports. At present it does not -- and cannot -- under current operating procedures.

OFPP has the authority to promote better operation of FPDS, and to effect a reduction in the burden of reporting procurement activity. OFPP desperately needs to issue a policy letter on reporting requirements, stating that it will assume the final approval authority on the nature, frequency, and content of all reports on Federal procurement activity. OFPP has the power now to stop the theft of our procurement professionals. The reporting burden steals at least one man-year of professional procurement labor from each full-fledged Federal procurement office (i.e., those with authority to procure goods and services with a value of over $10,000).

OFPP must inform both public and private sectors that it will no longer tolerate the collection of procurement data on reports which OFPP has not specifically approved. Secondly, OFPP should review procurement reporting requirements annually for their usefulness. Each approved report should contain an expiration date after which, unless extended, the requirement would be eliminated. Such a procedure would have long ago meant the end of or major modification to SF 37, "Report on Procurement by Civilian Executive Agencies." This report does not contain complete information on procurement as it is now defined. Reports with unclear or ambiguous instructions would likewise be eliminated, since much time is spent on obtaining interpretations which are usually as inconsistent as the data included in the report. Finally, OFPP should publish annually, at least 120 days before the start of each fiscal year, its list of approved reports. Such a list would serve as OFPP's commitment that reporting needs had indeed been reviewed, and that the current list represents the minimum number of reports to satisfy Federal and non-Federal information requirements.

I have been preparing and receiving reports on Federal procurement activity for my entire procurement career. Frankly, I'm tired of the inconsistency, duplication, and near-duplication of the reports which are required in the course of operating a procurement office in the Federal government.

Isn't a procurement office charged with the acquisition of goods and services, at the lowest price, from a responsive, responsible offeror, in accordance with applicable laws and regulations? Or is that merely a sideshow of its existence, with the real emphasis being the reporting of how we do business? In other words, is that function "procurement," or simply "meta-procurement?"

We need to reduce the reporting burden, and we need to do it yesterday. I sincerely believe that automation will go a long way toward removing the professional contract specialist from cutting and pasting contracts together, or, worse yet, typing standard clauses and work statements. If we can apply automation to such areas as document preparation, is it not too much to ask that we use it to reduce or eliminate the number of reports which are now prepared manually? Each agency must, however, relinquish its pride in originality. Agencies must be ready and willing to adapt proven, existing automated systems to their needs, thereby saving time and money in developing similar systems. Let's help our fellow professionals in the procurement field get back to the job at hand -- producing quality procurements -- and leave the preparation and reporting of their efforts to modern technology.

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INFORMATION SYSTEM REQUIREMENTS OF THE ACQUISITION COMMUNITY

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ABSTRACT

Political, economic, social, and technological changes have led to recognition of the need to reform the Government's acquisition system. Recommendations of the Commission on Government Procurement are being implemented through the Office of Federal Procurement Policy. One response to these recommendations is the Federal Acquisition Institute's project to encourage research into the acquisition process and to provide a mechanism by which relevant information is conveniently made available to the acquisition community. This paper reviews a user needs study and discusses the principal technical characteristics. The system should allow country-wide interactive full text search and retrieval of an apparently integrated data base. In addition, the FAI strategy for development of such a system is presented and expected benefits are discussed.

INTRODUCTION

Following the end of World War II, the United States was unquestionably the most powerful and influential nation on earth. U.S. industrial capacity had armed the free nations of the world and U.S. science and technology had dramatically altered weapons capabilities. The U.S. alone possessed nuclear weapons. U.S. policy recognized the need to rebuild former enemies and the Marshall Plan responded to the need with massive foreign aid expenditures. Over the years since WW II, the balance of power among nations and regions has been substantially altered.

CHANGING RELATIONSHIPS

These past thirty-plus years have witnessed two major military confrontations involving U.S. forces. Revolutions of the political left and right have affected dozens of countries. Colonial empires have disintegrated and scores of newly independent nations have been formed. The Soviet Union has exhibited the will to employ military forces to achieve its objectives. The middle eastern area continues in turmoil. These political changes have been accompanied by altered economic relations as well.

Perhaps the most critical economic alteration has occurred within the past seven years. The Western economies had been fueled by relatively inexpensive petroleum until 1973. While energy prices were low in relative terms little concern was shown over petroleum supplies. However, in 1973, the Western economics were shaken by an oil producers' embargo and four-fold increases in petroleum prices. The West was faced with high prices and supplies of a critical commodity that could be curtailed at any time. The West continues to face the same situation, and the price has increased by nearly an order of magnitude as of 1980. Even more ominous, the world is running out of oil.(1) The situation is serious. For example, Professor Richard Fowler(2) of the Bartlesville Petroleum Institute has suggested that beyond 1985 domestic U.S. petroleum supplies should no longer be relied upon as a fuel source and should be reserved as a chemical feedstock resource. The President has declared that the energy problem constitutes the "moral equivalent of war."

IMPACT OF TECHNOLOGY

Along with the social, political, and economic evolution over the past four decades, science and technological change has been equally dramatic. The "green revolution" has resulted in greatly increased crop production. Medicine has made dramatic progress in the treatment and control of disease and in the expansion of the human life-span. For example, the United Nations' World Health Organization has declared that smallpox no longer exists.

Man's knowledge of the environment has resulted in greater understanding of the interdependencies of ecological systems. Man has visited the Moon and sent devices into the solar system. Earth satellites provide communication, weather surveillance, precision navigation and scientific data. Electronic technologies have led to a revolution in computing capacity and applications.(3) These technological changes have altered almost every aspect of life in the developed countries. One implication is the impact of science and technology on nations' ability to conduct warfare.

While science and technology have created new weapons, the international situation has led to wide distribution of tactical weapons. Few if any tactical weapons capabilities remain exclusively the property of the U.S. The balance of technology between the superpowers evolves and shifts. Perhaps as late as five years ago, the conventional wisdom was that Soviet technology was inferior to that of the U.S. Today however, some authorities will claim that overall soviet technology is often equivalent to the U.S.'s. In the strategic arena for example, U.S. strategic doctrine has evolved from an assumption of overwhelmingly superior forces to a strategy based upon essentially equivalent strategic capabilities.(4) In the tactical area, U.S. systems are generally considered to be superior to Soviet capabilities but U.S. forces face numerically superior forces in almost every category. Real Soviet expenditures have continued to increase while the proportion of U.S.

GNP invested in its military forces has declined. Recently the President asked Congress for funding to reinstate Selective Service registration and pledged to increase military spending in real terms. NATO Countries have been asked to increase their Defense expenditures.

IMPLICATIONS FOR FORCE ACQUISITION

Military force is but one instrument of national policy. A challenge to the country is to acquire sufficient military force to safeguard our national interests within limitations of available resources. There are uncounted combinations of possible alternative force characteristics each with its associated costs. Assessment of contributions to defense by the alternatives are often judgmental and perception may be as important as substance. Decisions are made within certain political, economic, social and technological contexts. Of course, the opposition countries devote much effort toward further complicating the equation and making decisions more difficult.

THE COMMISSION AND OFPP

Concern with the quality and efficiency of the Government's acquisition system led to the establishment of the Commission on Government Procurement (CGP). During the early 1970s, the Commission studied all aspects of procurement and offered a number of recommendations. One result was creation of the Office of Federal Procurement Policy (OFPP).(5, 6) OFPP, part of the Executive Office of the President, in turn created the Federal Procurement (later Acquisition) Institute (FAI). One component of the FAI charter was to study the needs of practitioners for information about the acquisition process and to make recommendations to OFPP where appropriate.(7) Accordingly, the FAI established an interagency working group on acquisition information systems. The charter of the group was to conduct a user needs study, to create a functional description of an appropriate information system, and to propose such a system to OFPP.

Information systems can be divided into two categories. First are systems to collect, process, and provide tools for statistical analysis of data describing the numbers and characteristics of procurement actions. These data are of a quantitative nature and would, for instance, permit analyses of the proportions of awards by contract type and the extent of small business participation. Secondly, data that prescribe the conduct of procurement exist in the form of Public Law and implementing regulations. In addition, active procurement research and studies programs sponsored by the agencies document analyses of various components of the acquisition process. Data in this second category are generally narrative and constitute the data base of interest to this FAI working group, whereas The Federal Procurement Data System addresses the first or quantitative data base.

THE FAI STRATEGY

The FAI has no interest in physically developing and operating an information system. Rather, its basic strategy is to represent acquisition community interests in negotiations with various providers of information retrieval services. These providers include both existing in-house facilities and private-sector organizations. Examples of in-house providers would include the Federal Legal Information Through Electronics (FLITE) facility operated by the U.S. Air Force, the Department of Justice JURIS system, and the Defense Technical Information Center (DTIC). Examples of systems operated by the private sector would include Lockheed Corporations's DIALOG and Systems Development Corp's ORBIT. Of course, there are still other institutions with substantial capabilities but the above list is representative. An essential component of the FAI strategy is a functional and performance specification for data processing, data base content, telecommunications, and user interface. To develop such a specification requires an understanding of the characteristics of information users within the acquisition community and an assessment of the potential value of information services to these users.

USER NEEDS STUDY

The FAI asked the Logistics Management Institute (LMI) to conduct a study of the categories of acquisition information users and to characterize the information of potential benefit to each class of user. This study was conducted by Professor Albert Rubenstein (8) of Northwestern University. Based on interviews and discussions with members of forty government and business organizations, Rubenstein described the information needs of acquisition managers, policy makers, and researchers. Next a set of information sources were described. First were sources analogous to creators of scientific and technical information who communicate their findings through technical reports, books, and journal articles. Secondly, "ephemeral" literature was described as consisting of memoranda, policy and procedure documents, and both formal and informal information reporting systems. In addition, the study laid a conceptual foundation for the system design process. Rubenstein concluded that a principal purpose of any acquisition information system is to provide channels of communication between employers of information and sources of that information. It was noted that at any given point in time, the roles of creator and consumer of information may be played by any member of the acquisition community.

A SYSTEM SPECIFICATION

The LMI user needs study served as input to the specification development process. A word of philosophy is appropriate here. Acquisition practitioners function within dynamic environments. It is often not possible to define precisely the uses of information that may arise at some future point. This uncertainty affects both selection of data bases and specification of processing which might become necessary. Consequently, an information system with limited capacity and flexibility may meet an initial design requirement, but become unusable at some future time. It is important therefore to provide the greatest processing flexibility and capacity within the constraints of available resources.

The specification for an FAI chartered system describes the most enabling technical way of meeting stated present requirements and forecasts of future needs. Further, the approach chosen should not preclude different methods of access which might be required by users. Three aspects of the functional requirement are pacing items. First, the data bases must be available over computer terminals to users located throughout the U.S. Secondly, the software system must provide interactive search and retrieval services of essentially unlimited length textual documents. Thirdly, access should be to an *apparently*

single, inclusive data base. Each will be briefly discussed. Practitioners of the acquisition process are employed by industry and governmental entities at every level and are located at sites in each region of the country. Information systems success is often enhanced when responsive services are closely integrated within the user's office environment, the characteristics of the retrieval system should allow the user to interact personally with data bases if he or she desires. A user might for instance choose to place the terminal within the organizations' library or he/she might wish to make personal use of the terminal. Country-wide terminal access is commonplace for the commercial services. ARPANET, TELENET, AND TYMNET are representative national computer access networks.

The second pacing system attribute is interactive full text search and retrieval. Interactive implies that the system responds to the terminal operator within a few seconds. Actual data base searches might require somewhat longer periods. Once potentially relevant documents have been identified by a search, the terminal becomes the principal display device. Two examples of this "browse" mode are the NLS developed by Stanford University's Augmented Human Intellect Laboratory and the LEXIS legal information system of the Mead Corporation in Dayton, Ohio. In these two example systems, interactive search and retrieval are integrated with the intellectual process of research. In addition, the FAI specification provides for batch output services for those situations when users prefer it. The requirement for full text search and retrieval is necessary because certain information classes require full text. The legal and regulations files are examples. Further, a full text capability allows the use of a fixed-vocabulary or thesaurus approach where it is appropriate. The fixed-vocabulary technique is appropriate where file size is too large to allow full text processing with today's computer technology. For example it is not yet economically practicable to provide interactive search and retrieval of the full text of DTIC's 1,000,000 technical reports. However, search of the full text of abstracts might be a reasonable compromise in such cases; it would be a useful addition to the controlled vocabulary capability now employed.

The third pacing factor is the need to integrate presently separate and occassionally overlapping data bases. Accordingly, the system should provide a single access point to all relevant data. To the user, it should appear that there is a single integrated data base. To illustrate the requirement for an apparently common data base, consider that there are dozens of souces of acquisiton related information.(9) Conceivably, a practitioner must consult each of these sources to be certain of an authoritative understanding of all related materials.

Note however, that this requirement does not necessarily require that the existing data bases be physically integrated. Telecommunications networks and interface software can be developed to provide transparent access to multiple separate data bases.

A substantial proportion of the documents of interest to the acquisition community exist in computer storage today. For example, descriptions of all technical reports of the Defense Department are stored in a computer at the Defense Technical Information Center. The unclassified and unlimited distribution portion of this collection is, in addition, available from the National Technical Information Center over Lockheed Corp's DIALOG system. Legal documents are available through the FLITE and JURIS systems. Further, many agencies operate special interest information systems incorporating some or all of the technical characteristics described by the FAI.

BENEFITS

If an integrated information system is constructed, a number of benefits might be expected to result. Policy makers could be assured that all mandated policies are being met and that the research and study conclusions related to a given decision are considered. Operations personnel could be confident that policy and procedural requirements are being addressed and acted upon. Innovations in procurement proposed by various sources would be available for consideration. Finally, the productivity of the procurement research community would be increased through reduction of the mechanical aspects of research. The FAI believes that implementation of these services would contribute substantially to integration of procurement knowledge, innovation within the process and most importantly to improvement of the efficiency and effectiveness of acquisition.

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International Transfer of Intellectual Property for Defense Materiel

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Abstract

This paper explores the international methods of intellectual property (IP) transfer, new strategies to foster this transfer, the roles of the industrial and DOD project managers, and emerging initiatives and recommended directions. Intellectual property covers a broad range of managerial and technical knowledge and expertise including patents, technical data, know-how, manufacturing methods and techniques, and trade secrets.

"The controlling intelligence understands its own nature, and what it does, and whereon it works."

—Meditations V

With the explosive increase in technology in the nation and the world and the trends in world economy for balanced payments, the Department of Defense and U.S. and foreign corporations are changing the policies on management of transfers of technology. More frequently now being transferred is the technology including the design, engineering and production capabilities. Technology and management assets are earning returns to foreign and U.S. firms while fostering standardization and interoperability of the allies' weapons systems. Purchasers of technology become future industrial competitors, motivating new strategies and a growth of restrictions, regulations, and limitations.

Intellectual property is the result and fruit of man's intellectual pursuit and creativity. Men jealously guard these intellectual rights and powers much more than items produced by manual labor or purchased from others. Individuals, corporations and governments possess and maintain intellectual property and feel that intellectual property is the distinguishing factors which differentiate them. Thus, transfer of intellectual property (IP) is a very emotional issue to its holders. This intellectual property (IP) also represents valuable national assets. Transfer must be based upon mutual trust and confidence.

This article explores the international methods for intellectual property (IP) transfer, new strategies to foster this transfer, the roles of the industrial and DOD project managers, and emerging initiatives and recommended directions. Intellectual property covers a broad range of managerial and technical knowledge and expertise including patents, technical data, know-how, manufacturing methods and techniques, and trade secrets. Patents and technical data are normally readily transferable in the form of drawings and verbage. The know-how and techniques are based upon experience and insights of individuals and are normally not transferable without intellectual transfer such as in training and/or personal consultation programs. The NATO Intellectual Property Group, AC/94, has defined IP to include "inventions, patented or not, trademarks, industrial designs, copyrights and technical information including software. . ." The rights to use or have used intellectual property (IP) are termed intellectual property rights (IPR) and include rights derived from patents, trademarks, copyrights, industrial designs, contract clauses, disclosure in confidence techniques or other means of control of IP.

It is essential to realize that without the cooperation of the holder of the intellectual property rights, intellectual property transfer cannot take place. Firm-to-firm exchanges [without interference of third parties] are essential to a successful IP transfer, particularly in the key role of know-how and technical assistance. The same problem exists in the transfer of manufacturing drawings in competitive procurements as the firms that actually expect to follow the drawings, rather than convert the drawings to suit their own shop processes and practices, rarely possess the technology capabilities and the processing know-how. Figures 1 and 2 illustrate the product and process intellectual property transfer mechanisms.

In the development cycle of a weapons system, the government normally acquires technical data, software and license to inventions. With regard to inventions, DOD follows the 1963 Presidential Memorandum and Statement of Government Patent Policy (as amended somewhat in 1971). Under the President's Policy, the government obtains title to contract inventions in four situations: (1) when the principal purpose of the contract is to develop or improve products or processes which are required by government regulations; (2) the government is the principle developer in the field and where the retention of the rights by the contractor would confer a dominant position; (3) public health safety or welfare is concerned; or (4) the contractor is operating a government-owned research or production facility or is directing other contractors (DAR 9-107.2(a)).

Title for inventions remains with the contractor in the very large majority of causes not covered by DAR 9-107.2(a). Where the purpose of the contract is to build upon the contractors expertise as demonstrated by know-how, experience and patents held, the contractor retains exclusive rights throughout the world on the inventions DAR 9-107.2(b). Independent research and development (IR&D) programs do not accrue rights to the government.

Where it is not clear whether, based upon the examples above, that the exclusive rights are retained by the government or contractor, the rights can be deferred for resolution at a later date. The burden of proof then reverts to the contractor to challenge the government's exclusive right.

Standard patent rights clauses based upon the acquiring or reserving the rights to inventions are readily available as "boiler plate" to research and development work in the U.S., its possessions and Puerto Rico as outlined in the discussion above. Patent rights clauses for foreign contracts may be tailored to meet requirements peculiar to the foreign procurement provided the replacement clauses are consistent with the principles of the DAR 9-107.2.

PRODUCT	LICENSEE'S REQUIRED LEVEL OF TECHNOLOGY	MODE OF IP TRANSFER	EFFECT ON RECEIVING NATION	TYPES OF CONTRACT	CONTROL MECHANISM	RISK
TRAINING OF NATIONALS	LOW	TRAINING OF SKILLED WORKERS AND MANAGERS (COUNTER PART PROGRAM)	CREATES TECHNOLOGY BASE	CPAF CPFF	OUTSIDE INFLUENCES TO LICENSEE AND LICENSOR	LOW TO MEDIUM BASED UPON SOCIETY OF LICENSEE
TURN KEY PLANT	MEDIUM	SYSTEM AND INDUSTRY SPECIFIC	BRIDGE TECHNICAL GAP	CPIF CPFF FPI	SCHEDULE	LOW
ASSEMBLY OF COMPONENTS	MEDIUM	INDUSTRY SPECIFIC	CO-PRODUCTION	CPIF CPFF FPI	SCHEDULE	LOW TO MEDIUM
TECHNICAL DATA PACKAGE	MUST BE COMPARABLE TO LICENSEE	TECHNOLOGY SPECIFIC	DUAL PRODUCTION	FEES AND ROYALTIES	NONE	MEDIUM TO HIGH, BASED UPON TECHNOLOGY BASE OF LECENSEE
END PRODUCT	LOW	OPERATION AND MAINTENANCE	LIMITED	FFP	COST AND SCHEDULE	NONE

Figure 1. Product Intellectual Property Transfer

PROCESS	LICENSEE'S REQUIRED LEVEL OF TECHNOLOGY	MODE OF IP TRANSFER	EFFECT ON RECEIVING NATION	TYPES OF CONTRACTS	CONTROL MECHANISM	RISK
RETOOLING AND NEW EQUIPMENT	MEDIUM TO HIGH	TERMS OF SALE	CREATE NEW EFFICIENCIES	FFP	TERMS OF SALE	MEDIUM
INFORMATION EXCHANGE	COMPARABLE	REPORTS AND SEMINARS	NEW APPLICATIONS	FEE OR FREE	LIMITATION OF ESSENTIAL KNOW-HOW	MEDIUM TO HIGH
CONTRACTED TECHNICAL ASSISTANCE	MEDIUM TO COMPARABLE	TRAINING AND TECHNICAL ASSISTANCE	SELECTED LEARNED SKILLS	CPIF CPFF	NORMALLY USED WITH LICENSING AGREEMENTS	MEDIUM
TECHNOLOGY TRANSFER	MEDIUM	TRAINING OF SKILLED, ENGINEERING AND MANAGERIAL PERSONNEL	CREATES MAJOR NEW INDUSTRIAL CAPABILITY	CPAF CPFF	ECONOMIC AND POLITICAL OUTSIDE INFLUENCES	MEDIUM

Figure 2. Process Intellectual Property Transfer

In production of weapons systems, the government only acquires technical data and software, but no license to inventions. Technical data is procured, whether on R&D or production contracts, as called forth in the Contract Data Requirement List, DD 1423. The government has extensive needs for many kinds of technical data to support standard and unique types of equipment to be procured, operated, and logistically supported including the functions of supply and cataloging, provisioning of spares, overhaul and repair, inspection and quality control and training of operator and maintenance personnel. Commercial organizations are also vitally interested in technical data pertaining to their equipment, and such data is closely held (proprietary) as disclosure of such data may jeopardize the competitive advantage a firm may enjoy. The policy of DOD is to acquire only the technical data rights that are essential.

In the negotiation of a contract, a predetermination of rights in technical data, applying to that technical data for which rights may be practicably identified, should be agreed upon. Technical data is categorized into unlimited and limited rights. Unlimited rights should be acquired (1) if there reprocurement of the item, component or process is anticipated for which the technical data will be required, no other suitable alternate design is available, and additional technical data will not be required for a reasonably competent manufacturer to produce a suitable alternative, and (2) anticipated savings in reprocurement is greater than the cost of the unlimited data rights. Technical data can be delivered to foreign governments as in the national interest under DAR 9-201(b) even if only limited rights in data are obtained, subject to the same limitations as the U.S. Government. Data rights clauses may also be modified to meet the foreign procurement requirements provided the replacement clauses are consistent with the policies and principles of DAR 9-202.2 and 9-602.

Software is acquired with restricted or unrestricted rights and is also listed as a Contract Data Requirements List item. Restrictions on the right of the government to use computer software are acceptable provided they permit the government to meet the requirement for which the software was acquired or leased.

The laws of our European allies in NATO covering rights in inventions, data rights and software are substantially different from the above treatise. The inventor maintains ownership of inventions with rights to use the invention. IP/IPR is normally owned by industry and the individual. However, provisions committing a contractor to enter license agreements is part of the Federal Republic of Germany's (FRG) development contract regulations (ABEI) and the United Kingdom's regulations in the "International Collaboration Clause." The reasonableness of the licensing fee is also addressed in the FRG regulations.

Whenever intellectual property transfer is anticipated for the purpose of developing or encouraging the development of foreign or American sources of supply, development of these sources is normally accomplished by licensing agreements where the concern holding the IP agrees to furnish patent rights and technical assistance in the form of data, know-how, training of personnel, and manufacturing equipment. The licensing agreement should include definitive statements on the following:

1. Contractor signs up for a production capability sharing including, specifically, to establish a capability for research, design, engineering and production capabilities defining precisely the equipment and technology involved and ownership of equipment and special tools.
2. The contractor agrees to provide technical assistance and set up specific training/consultation programs to facilitate IP transfer to include the scope of the information to be furnished.
3. Unrestricted and restricted rights to furnish information to other participating governments.
4. Unlimited and limited data rights in technical data and patents.
5. Continued support/exchange in R&D, design and manufacturing, operation and maintenance, and spares breakout programs.
6. The period of duration of the agreement.

Whenever the U.S. Government holds a royalty-free license, unlimited data rights, and pays for technical assistance to be provided to a second source, the primary source and his subcontractors are barred from charging the second source. In this case the price paid by the government is limited to the actual cost of providing data, personnel, manufacturing aids, samples, spare parts and the like; royalties are not an allowed cost.

Foreign license and technical assistance agreements between U.S. and foreign contractors (including foreign governments) must meet the requirements of Section 124.04 of the International Traffic in Arms Regulation. The Department of State controls the exportation of data relating to items in the United States Munitions list, which includes arms, ammunition and munitions of war.

Consideration of intellectual property rights (IPR) must be considered very early on in a collaborative program with the appropriate personnel including the project manager consulted and involved in assuring that international licensing agreements are consummated and proper IPR clauses are in place in the contract to facilitate the IP transfer. Although early collaboration within NATO is not always possible because of requirements or budgeting phasing, provisions for the IP transfer should be considered for possible prospective partners. A necessary condition for IP transfer is consultation with industry prior to the signing of a memorandum of understanding (MOU) for collaborative programs, as industry provides the actual IP transfer. IPR provisions must be clearly and precisely stated in the MOUs, similar to contract data clauses to a contractor. Provisions for the modifications, improvements, overhaul or repair and to manufacture spares by the industry receiving the IP transfer should be precisely stated also.

With the initiation of the periodic armaments planning system (PAPS) with NATO for the harmonization of member nations requirements and facilitating exchange of information on weapons development it is expected that competitive international selection of systems on a national basis will occur more frequently. Problems that must be addressed in the MOU during the competitive phase are how

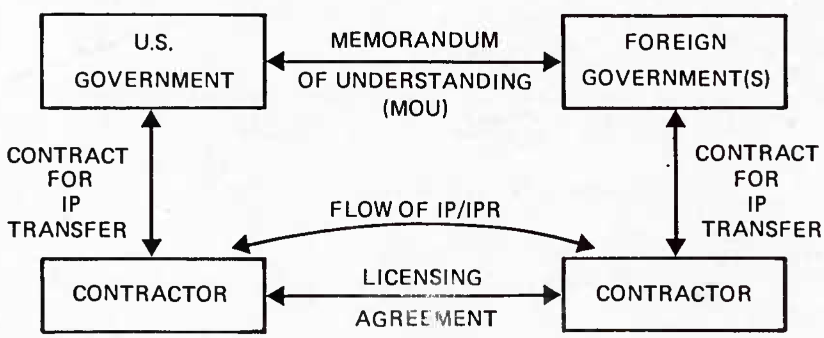

Figure 3. Modes of Intellectual Property Transfer

to safeguard IPR during and after the evaluation, licensing of the IPR from the winner, recoupment of the R&D costs of the government and contractor, and easing the economic and industrial import on the unsuccessful competitors. It must again be stressed that licensing and disclosure of IP/IPR for NATO purposes must be accomplished with the full participation of the owner of the IP/IPR and that governments can not legally transfer IP/IPR which is owned by industry unless this right is granted legally and contractually.

Of significant concern is the right of sales to NATO and non-NATO countries subject to the economic and political considerations of the participating countries. Again, this must be precisely defined in the work sharing arrangements to assure equitable sharing of the benefits to include increased NATO standardization and interoperability.

Since the beginning of NATO, a number of firm-to-firm licensing agreements have been concluded for manufacture of U.S. designed and produced systems. An early example is that of Lockheed entering into agreements with German licensed firms for production of the F-104G in 1959. Shortly thereafter Lockheed had production license agreements with Italy, Japan, the Netherlands, Belgium and Canada. Agusta (Italy) has concluded production licensing and marketing territorial agreements with Sikorsky, Bell and Boeing-Vertol for manufacture of helicopters. The F-16 aircraft coproduction program appears to be the deal of the century, however, with large IP transfers to Belgium, the Neatherlands, Denmark and Norway. These European Participating Governments (EPG), as the four countries are known, have a specified share in the production of the F-16 aircraft, 10 percent of the value of the 650 F-16s being procured for the USAF, 40 percent of the 350 aircraft being produced for the EPG and 15 percent of all F-16s sold to third countries. Key provisions of the memorandum of understanding (MOU) and General Dynamics contract call for a royalty-free license to the EPG for all IP, EPG grants a royalty-free license for all contract generated IP, the United States Government agrees to assist the EPG in obtaining IP and technical assistance from U.S. firms involved in F-16 components production, and restricts certain advanced technologies from transfer.

Two new methods for IP transfer are identified. The first method being incorporated in Navy and FRG MOUs creates a system of restricted and unrestricted rights. Restricted rights refers to information that cannot be furnished without incurring liability to a third party while unrestricted rights does not create such a liability. Prime offerors, when bidding, must state what technical information is unrestricted and restricted and provide terms for providing restricted information. This is normally included as a priced option to be exercised when a clear agreement between governments can be obtained.

The second method is a contractual option in the limited production contract to license production of the contractor's design to another contractor. This permits domestic or international second sourcing of the production. The contractor receives a non-negotiated royalty rate.

Two of the three legs of the NATO RSI acquisition are (1) dual and coproduction and (2) family of weapons. As one country completes development of a system meeting the operational requirements, that system is made available for production for the other members of the alliance by means of licensing agreements or as a contract option. Coproduction is the manufacturing and/or assembling of completed systems at separate production lines in different countries. Dual production is the manufacturing of several specific systems. While the F-16 aircraft represents coproduction, a dual production arrangement is typified by an arrangement between General Electric and SNECMA of Paris to jointly produce the CFM-56 aircraft engine.

Under the family of weapons (FOW) concept, NATO countries jointly agree to program packages. Each country agrees to joint military requirements, in the form of a mission element need statement (MENS), and utilizing a system such as the periodic armaments planning system (PAPS), initiate joint schedules and allocate responsibilities for development of equipment to meet the joint requirements. This approach, while fostering direct interoperability and standardization of equipment, also avoids expensive duplicative R&D efforts. An agreement of the participating countries is necessary specifying the respective scope of work and financial obligations such as:

1. System and subsystem acquisition management responsibilities in accordance with a time and cost schedule and a reporting system.
2. Financial sharing and cooperative agreements on recouping on R&D costs on third country sales.
3. Full competition of all participating countries' industries in the evaluation for the development contracts.
4. Plan for adoption of the subsystems within the system for which each country has a military requirement, including use of common components in several systems, where possible.

Figure 4 illustrates the integration of the family of weapons (FOW), dual and coproduction, process and product innovation

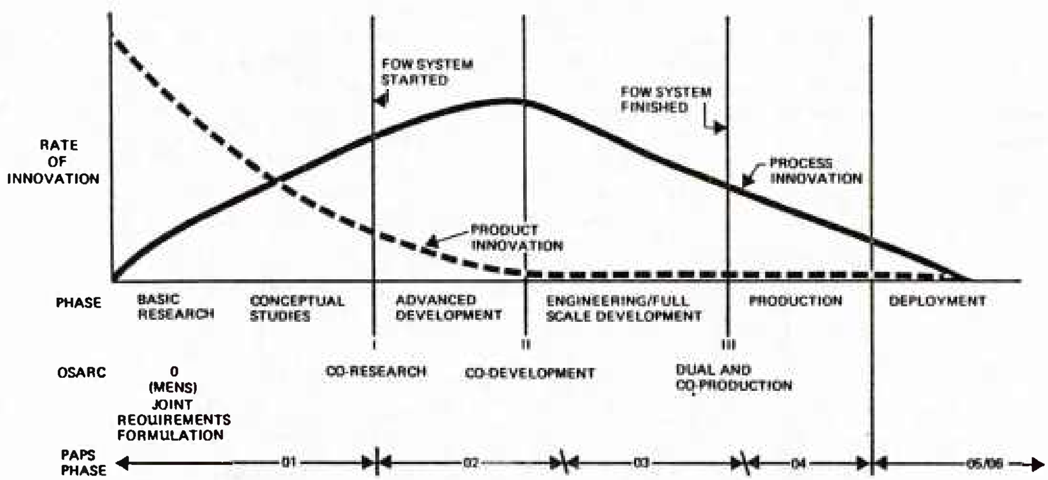

Figure 4. Transfer Opportunities During the Life Cycle

opportunities into a preliminary armament planning system (PAPS) life-cycle.

Conclusions

It must be recognized that the following factors are common to IP transfer:

1. The importance of industrial involvement is critical to any extensive transfer.

2. Transfers have been for mature equipment normally already in production in the U.S. Transfer at earlier phases creates many very different problems and concerns.

3. The project manager and his team are the instruments for DOD to institute IP transfer. If this team does not consider IP rights and the transfer mechanisms early on, IP transfer becomes much more difficult and expensive. The PM must also be fully cognizant of NATO developed equipment to meet his approved requirements, especially if the equipment is related to a European scenario.

4. Unrestricted and restricted rights and an option for licensing must be provided for. Provisions for multiple licensees, limitations of the time to exercise the option, protection of the IP transferred, resolution of disputes, configuration control and engineering changes, and the level of the work breakdown structure as to piece parts and subcontracted material should also be included in the option clause as well as limitations on payments to the contractor such as royalties.

Recommendations

It must be recognized that industry will carry out any initiative for IP/IPR transfer. The driving force for U.S. industry will be to penetrate new markets in NATO. To accomplish this, U.S. firms may decide to "team" with foreign firms to facilitate the transfer for business. This arrangement would likely result in a competitive advantage, also, for the contractor for U.S. procurements where NATO standardization and interoperability are an issue. It would also allow the U.S. firm to operate overseas on its own terms, rather than terms dictated by a MOU. Several of the problems of legal rights in invention, data and software disappear if the foreign firm is involved throughout the development process, also. As our European allies develop their own defense industries, the "teaming" mode can be expected to be the preferred manner for penetrating the European defense market.

NEGOTIATION FACTORS IN THE NATO ENVIRONMENT

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ABSTRACT

The purpose of this study is to identify those factors which may affect the negotiation process when dealing with foreign firms and foreign government officials. Some cultural differences which might influence negotiations are reviewed. Several examples are provided to illustrate these differences. Most findings and conclusions are based upon personal interviews with U.S. negotiators, from both the public and private sectors, who have had extensive experience in negotiating with the Germans, Dutch, French, and British.

INTRODUCTION

As a result of recent policy decisions relating to NATO Rationalization, Standardization, and Interoperability (RSI) objectives, there has been a significant increase in the volume of direct purchase transactions requiring negotiation between the Department of Defense and foreign private firms (1). Of course, much negotiation has also taken place on a Government to Government basis in establishing a framework to foster these cooperative development and reciprocal procurement programs.

The purpose of this study is to identify those factors which may affect this negotiation process. Besides a literature search to uncover some of the cultural differences, most findings and conclusions are based on personal interviews with U.S. contract negotiators from both the public and private sectors. The study is directed towards NATO participants and concentrates upon those factors likely to be encountered in dealing with negotiators from Germany, France, the Netherlands, and Great Britain.

NEGOTIATION FACTORS WITHIN THE PRIVATE SECTOR

Cost Evaluation. When purchasing from European suppliers, U.S. firms must carefully evaluate various types of costs which usually are not encountered in dealing with domestic suppliers. Evaluation is necessary whenever competition exists so that domestic and foreign offers can be compared on a "true cost" basis. In a non-competitive environment this evaluation is a necessary step in preparing for negotiations since many of these costs can be influenced by establishing special provisions in the contract.

The first problem concerns the treatment of item cost. In this case the difficulty is a lack of information, since most European firms are quite reluctant to provide a detailed cost breakdown. The European concept of a fair and reasonable price is tied directly to the marketplace, however imperfect it may be. "Whatever the market will bear" is often the sole basis for a European firm's pricing policy. Thus, the U.S. negotiator must perform an independent price analysis based on domestic budgetary estimates. The most effective tactic in dealing with this situation is to generate competition and not worry about the cost breakdown at all. In mandatory sole source situations such as directed purchases to specific sources, the best approach seems to be an appeal for a price reduction based on the purchaser's budgetary limitations (both real and imagined).

Another type of cost which is often partially hidden involves special handling, storage, taxes, and transportation. Even in a purchase which specifies FOB Destination, some of these costs still must be considered. For example, the movement of the material should be monitored to ensure eventual receipt. This involves additional transportation specialists and expediters who must make long distance telephone calls or take trips for the major purchases. Since most European firms operate on an "ex works" or "ex dock" (FOB Origin) basis, these handling charges, taxes, and various permit fees become a direct cost for the purchaser. In fact, there are many European trading terms such as "FAS (Free Alongside Ship) Vessel" and C.I.F. (Cost, Insurance, Freight) Destination" which are not commonly used in the United States. These terms are clearly defined in a publication called INCOTERMS, which is available from the National Committee of the International Commerce Commission located in New York City.

Currency exchange arrangements can greatly affect the bottom line cost to the purchaser. Negotiations are normally undertaken to determine which currency will be used for pricing the contract, the timing of the currency exchange, and the basis for rate determination. Historically, the buyer could generally insist on using his own currency for contract pricing. However, the recent fall of the U.S. Dollar relative to most European currencies has caused many European suppliers to demand exchange rate guarantees. In effect the contract is then priced in the supplier's currency and the buyer must either set up a foreign currency fund pool or

else risk an automatic price change if the actual foreign currency exchange rate should fluctuate. In some cases a skillful negotiator can develop a pricing procedure which effectively shifts a part of the risk of exchange rate fluctuation to the supplier. The mechanism to accomplish this is simply a share formula or else a limit on the degree of fluctuation when computing the amount of foreign currency owed to the supplier.

Unfortunately, foreign exchange pricing arrangements are often further complicated by the timing of payment. European firms tend to have cash flow problems and must frequently assign contract payments to lending institutions. Advance payments obviate the need to make these assignments and are, therefore, very desirable to the seller. In fact, many European suppliers will make significant price concessions if advanced payments are to be made. If the exchange rate and timing of payment factors are carefully tied together, the result can be the elimination of exchange rate fluctuation problems and a price reduction in consideration for the advance payments.

Time Considerations. In general, it takes longer to deal with foreign suppliers than with domestic suppliers. Since time is often a significant factor in negotiating any contract, identification of the specific reasons which bring about protracted lead times might help the contract negotiator minimize these delays. The obvious relationship between time and distance would, in itself, suggest longer lead times from foreign suppliers. However, distance is not the only cause for longer lead times. Lack of familiarity with U.S. specifications will generally result in slower response times to U.S. solicitations. The foreign firm must expend more effort to ensure its offer meets the U.S. requirements. In many cases the European firms take longer to respond simply because of their traditional operating procedures under which a reasonable time period is apt to be quite a bit longer than that which would be considered reasonable in the United States.

The negotiation process itself is also significantly longer if the foreign firm has not had extensive exposure to U.S. business practices and specifications. Many standard operating procedures identified in the buyer's regular "boiler plate" clauses must be thoroughly discussed with European suppliers. American business practices regarding payment, warranties, liquidated damages also require much discussion as the treatment of these factors varies from country to country. Normally, the U.S. negotiator must establish the extent to which the foreign supplier has previously complied with applicable U.S. specifications. This requires a detailed step-by-step review of the specifications. Sometimes the foreign supplier's standard specification meets or exceeds the U.S. requirement. However, a very detailed review and comparison is required in order to ascertain the adequacy of the foreign specification.

Other Terms and Conditions. Some other factors which might arise during negotiations with foreign suppliers include, letter of credit procedures, default provisions, cancellation limitations, place of jurisdiction, and the procedures for resolving disputes. The letter of credit mechanism is quite complex and involves several parties and as many as thirteen steps to complete a single transaction. Specific letter of credit terms and conditions should be negotiated and incorporated into the basic contract in order to preclude misunderstandings during contract performance. Default clauses often have release provisions in case of a force majeure. Since the determination of what constitutes a force majeure varies from country to country, this clause must be carefully worded to protect the purchaser. Cancellation procedures are especially difficult to negotiate with European suppliers because of the supplier's inability to manipulate the size of his labor force. The issue of jurisdiction is somewhat easier to resolve in dealing with foreign private firms than with foreign government agencies. Since the buyer is paying the bill and thus, providing the money in this transaction, the buyer can usually persuade the seller that legal jurisdiction should remain in the state or country in which the buyer is incorporated. Sometimes, a trade-off takes place because the seller is very concerned about jurisdiction with regard to the handling of disputes. Usually a recognized international arbitration board is designated to resolve disputes. Negotiation of these points is quite complex and much interface with legal counsel is generally needed to avoid an unfavorable arrangement.

Trade-offs are commonplace in almost all negotiations, however, in dealing with foreign suppliers, the quid pro quo concept is especially important. In some countries, the "winner" is thought to be the negotiator who gains the most concessions, regardless of the importance of those concessions. If the foreign negotiator treats all concessions as equal, then the U.S. negotiator should ensure that many issues are introduced. Concessions can be offered or exchanged in an attempt to win the big points and yield on the little points. For example, a French supplier might insist that the specification be modified to provide that "MADE IN FRANCE" be etched into the item's casing. If the American negotiator is concerned about the delivery schedule, a very painful liquidated damages clause could be presented in exchange for this minor (but emotional) specification change. When used effectively, both sides feel as though they have won at the negotiation table. (2) One must always look for emotional issues which might yield valuable concessions on substantive issues. Of course, the skilled U.S. negotiator must fully understand the foreign business practices and cultural influences on negotiations in order to recognize which issues will yield the best concessions. Since emphasis on these factors and general negotiation techniques vary from country to country, it is important to recognize the differences between German, French, British, and Dutch negotiators.

DIFFERENCES BETWEEN COUNTRIES

General Comments. Before discussing the way in which specific cultural differences affect the negotiation process, some distinction between public and private sector contract negotiations is

necessary. The primary distinction rests on the public sector concept of sovereign equality versus the private sector's economic marketplace orientation. Thus, public sector negotiations cannot rest on a single sovereign's framework of rules and regulations, but instead will always involve some mixture or blending of two sets of rules. In public sector negotiations, political considerations are paramount, while in the private sector, economic considerations prevail. Thus, public sector negotiations involve many more emotional issues and protocol becomes very important. For example, most of the private sector negotiators said they had very few language problems in dealing with European firms because all negotiations were conducted in English and the contract was written in English. Although the public sector negotiations were frequently conducted in English, a great deal of time was spent preparing and altering translations in an attempt to produce a bi-lingual document.

There are a few points which seem to apply to negotiations with all European countries. For example, it is important to avoid embarrassing any members of the foreign negotiating team. While this might seem obvious, it must be remembered that it is very easy to embarrass someone without realizing it, particularly if the foreign customs are not fully understood. To minimize misunderstandings, the U.S. negotiator should always use clear and simple language and repeat important points often, using slightly different phraseology each time. Frequent caucuses are especially useful in negotiating overseas as the caucuses help to relieve tension. Finally, some appreciation for the way Europeans tend to view Americans could be helpful in overcoming a stereotyped image. A recent study in public opinion revealed the following perceptions of Americans by Europeans.

Nationality	Adjectives most frequently used to describe Americans		
British	Progressive	Conceited	Generous
French	Practical	Progressive	Domineering
German	Progressive	Generous	Practical
Dutch	Practical	Progressive	Hardworking

(3)

Germany. In reviewing several detailed studies of German culture and heritage, several general observations regarding German characteristics emerge. Germans project an air of formality among themselves as well as among foreigners. For example, there is apt to be much more handshaking than most Americans are accustomed to. Also, the American habit of gum chewing still horrifies the older Germans even though the habit is growing in popularity among the youth in Germany. With regard to youth, it should be noted that the tendency towards "Americanization" is twice as strong among the 16 to 29 year olds than among the 45 to 59 year olds. Even so, only about 65% of the younger group indicated contentment in adopting American characteristics and mannerisms. (4)

Even the German language reflects this formality in the distinction between Du (intimate form of "you" or "thou") and Sie (the formal version). Among white collar business associates, the Sie form predominates. With only a rudimentary knowledge of German, one can quickly detect the level of formality between two individuals conversing in German. A U.S. negotiator who is fluent in German will reap other benefits as the Germans tend to caucus openly in German at the negotiating table because they tend to assume that Americans cannot speak German. Even if they know the American does speak German, this open caucusing habit is difficult to break and much can be learned if the discussions can be understood.

Spacial relationships are somewhat different in Germany. While the "bubble of privacy" for an American is generally about two or three feet, the German often needs a whole room for his "protective bubble." (5). Thus, while a private conversation held several feet away from an American (third party) would not upset the third party, a German third party might become extremely upset because his privacy zone would have been invaded, even though he was excluded from the conversation. This concept of "privacy bubble" may seem inconsistent with the practice of the open caucus and, in fact, might not apply directly at the negotiation table. Nevertheless, the U.S. negotiator should be sensitive to this "invasion of privacy" in other social interactions with his German counterparts.
German humor is almost non-existent except for regional jokes and puns. The quick flash American smile is generally considered to be an insincere gesture. At the negotiation table, expect very little levity. The Germans tend to speak English very slowly and strongly without injecting any slang. Patience is, therefore, a necessity in negotiating with the Germans.

Because of the stratification of the German education system and the close relationship between education level, employment opportunities, and social status, the Germans are very conscious of educational credentials. The title "Dr." commands instant respect whether or not the particular "Dr." is actually capable of defending a position at the negotiating table. Some implications are fairly obvious. A PhD expert will probably be a great deal more persuasive than a functional expert who might have had many years experience in working with the system being purchased.

A "sense of order" seems to be extremely important to the Germans. In fact, the fantastic rate of economic growth since the end of World War II is largely attributed to willingness of German people to adhere to federal regulations which tied wages and prices to productivity. Private firms in Germany will strictly adhere to offical guidance on rates and it is virtually impossible to get significant reductions at the negotiating table. Non-recurring costs, however, are much more flexible. Items such as design engineering, testing, and data preparation are likely to have excess costs built into the proposal. When digging into these cost elements, it is very easy to get lost in a sea of detail. Frequent summaries are needed in order to keep the negotiations moving. If minutes are being recorded, it is wise for the U.S. team to participate in the preparation since the

German version often tends to read like a novel with every detail fully described.

Establishment of an agenda is also very important when negotiating with the Germans. As they are very sensitive to limitations of authority, much pre-staffing is done with higher management levels and with legal counsel. While the flexibility of the German negotiator might appear to be very limited, at least the final approval process will be quite rapid because of all the pre-staffing. Frequent caucuses will allow the German negotiator time to get approval on any changes the U.S. negotiator has proposed. But, before a break, some agreement should be reached on the duration of the break and the topic to be discussed immediately following the break. Otherwise, negotiations will become protracted and this delights many Germans who feel they can eventually wear down the U.S. negotiators. Another advantage of the agenda is to minimize the unavailability of experts, which is a tactic often employed by the Germans whenever they do not want to discuss an issue.

Bureaucracy and "red tape" abound in Germany. Because of their "sense of order" and high respect for authority, official documents are treated quite differently from normal business papers. In one case a U.S. negotiator was having difficulty in clearing the border inspection into Germany because of the lengthy review of his briefcase contents. To alleviate this problem, he bought a rubber stamp and marked his cover sheets "OFFICIAL NATO BUSINESS." The problem disappeared.

Some U.S. negotiators found that a short working lunch was an effective means of getting the German's attention since such a lunch is not consistent with the routine heavy noon meal. Also, these U.S. negotiators found that the period just after lunch was the best time to introduce important issues. At least one U.S. negotiator learned to handle the very difficult issues away from the formal setting of the negotiating table. Once a mutual trust had been developed, private discussions _unter vier Augen_ (literally "under four eyes") were quite useful in resolving these difficult issues.

France. In contrast with the German's concern about precision with the written word, the French tend to be much more flexible and casual about contract wording. Historically, the French business philosophy did not stress growth or profit maximization. Entrepreneurs seemed more concerned that too much growth would cause the character of the business to change and would probably affect their comfortable life style. (6) This conservatism resulted in a slower economic growth than that of most European neighbors. Also, the extremely nationalistic policies put forth by Charles De Gaulle did little to help France economically. Even today some U.S. negotiators have found that nationalism often tends to sidetrack the French negotiator who becomes extremely preoccupied with a single issue which sometimes is quite minor. If the U.S. negotiator can discover what this big point is, the _quid pro quo_ advantage is potentially enormous.

With regard to differences in spacial concepts, the French tend to like centralized control with the boss in the middle of the group. The boss directs all activities and makes all decisions. The idea of dividing up space equally (the American way) never seems to occur to a Frenchman and a newcomer to a group must fend for himself until he has been accepted by the group. The implications of this difference in space utilization could have some impact at the negotiating table, particularly if there are several countries involved (e.g., a multinational cooperative development program). French reluctance to establish common (neutral) territory could inhibit progress in the opening phase of these negotiations. This difference in spacial concepts was one of the many problems faced by a U.S. negotiator who was negotiating with the French indirectly. In this case the French were purchasing some complex target drones and related range services from the Italians who, in turn, were subcontracting a large portion of the work to an American firm. Both French and Italian negotiators were from the public sector representing NATO interests. The Italian negotiator representing the prime contractor was there as well. Initially, there were many problems with seating arrangements which arose as a result of differences in spacial concepts as well as the French reluctance to deal directly with the Italians unless the U.S. subcontractor would be a full participant. Despite the absence of privity between the U.S. subcontractor and the French, a completely three-way negotiation session ensued and the American firm became hopelessly trapped right in the middle in a sort of whip saw maneuver by the French and Italians. In this instance the reluctance of the French to deal directly with the Italians was the primary cause of the problem. However, if the American had not allowed himself to be positioned in the center of the action, he could have effectively maintained a lower profile during the negotiations. But since the U.S. negotiator had been caught in the middle, the French expected him to take control rather than act as a neutral "middleman" which was the role perceived by the American. Incidentally, the Italians seemed to enjoy having an American placed in the middle to act as a buffer between the Italian and French negotiating teams.

Status consciousness runs very high with the French. Most of the U.S. negotiators found the French to be quite insistent that the French negotiator have the same organizational status as the U.S. negotiator. Since organizational structures and titles are quite a bit more flexible in America (particularly in a matrix organization), the U.S. negotiator should find out the French negotiator's position and adjust his own title (within reason) accordingly. Another ploy sometimes used by the French when negotiating at home is to start the negotiations at a fairly low organizational level. Then successively higher levels are introduced to review the progress and to reopen negotiations when early sub-agreements appear slightly unfavorable. Because of this status consciousness, the higher levels will either try to dominate the U.S. negotiator or insist that the negotiations be elevated to a higher level on

the American side. Quite simply, the moral to this story is not to start out at too low a level.

At the negotiating table the French seem to be quite secretive about their position.. On the other hand, some American negotiators tend to be much more open in dealing with Europeans than with other Americans. The reason for this difference was thought to be an American feeling that the Europeans were not familiar with U.S. business practices and needed a "helping hand." For example, the American negotiators would frequently reveal target costs at a very early stage in negotiating with Europeans but would keep their targets closely held when dealing with Americans. The rationale for this difference is that the target costs relate the scope of work and early disclosure helped to explain the U.S. requirement. Also, certain clauses such as liquidated damages required detailed explanation because the European approach to a delivery slippage was thought to be much more casual than the more serious American concern about the importance of meeting delivery commitments. This paternalistic attitude was quickly revised by those U.S. negotiators who had recognized that there is an additional cost in being open and frank if the other side is being secretive.

Negotiations with the French seem to involve quite a bit of pomp and ceremony according to most U.S. negotiators. The prevalence of charge accounts and the desire to project an image of refinement and chivalry result in more social interaction than with citizens of other European countries.

Emotionalism and theatrics also seem to be more prevalent among the French. In one case an American negotiator was in France trying to arrange for the purchase of some very expensive French heaters. Because the French firm refused to provide cost data, the American made a counteroffer based on "bottom-line" budgetary considerations. When the sales director stepped in to review the progress of the negotiations, he became incensed at the low counteroffer. He immediately raised his original offer, slammed his briefcase down on the table, and stormed out of the room. Although the American was stunned by this outburst, the sales director was quite calm and rational the following morning and the contract price was agreed upon at about the same amount as the budgetary counteroffer. Whether or not the outburst had been pure theatrics or true emotionalism, the American could never determine. But the important point here is that one must not panic in such a situation. The passage of time will generally restore the situation to a manageable level.

United Kingdom. The British negotiators are generally very deliberate and highly skilled. However, many of them tend to overestimate their skill. Because of this high level of self-esteem, the British like to take charge of negotiations. This desire to dominate is entirely consistent with several basic negotiation theories which suggest that the dominant side is usually the winner. Functions such as minutes recording and agenda initiation are volunteered for immediately in an attempt to control the negotiations. On the other hand, most American negotiators felt that the British were very open and forthright once the negotiations began. The British tried very few "games" or tactics such as those frequently encountered by these American negotiators when dealing with American firms.

In multinational negotiations some American negotiators felt that the British would attempt to form a coalition on the basis of common heritage and language. Some of the European participants inferred that the British and the Americans had joined forces against the others. While these coalitions never materialized, this situation provides another example of the sensitive nature of multinational negotiations when several diverse cultural groups are represented.

Socially, the British are quite formal and reserved. Physical proximity (e.g., a neighborhood) does not imply friendship. Due to the stratified social structure, formal introductions must precede the development of a social relationship. Because of the high population density, the British tend to ignore those around them and simply withdraw into themselves whenever they wish to be alone. Such behavior is quite acceptable in the United Kingdom, but to an American, this withdrawal in the American's presence could be misinterpreted as the "silent treatment."

Despite the fact that the British and Americans both speak English, some "translation" is necessary to account for the numerous differences in terminology, tone, and substance. For example, the expression "to table a proposal" has exactly opposite meanings in British and American. One American negotiator recalled a situation in which the American and British negotiators talked right past each other on this point for over a quarter of an hour.

As with the French, the British also have a preponderance of expense accounts. The extremely high corporate and personal income tax rates contribute to this situation as these expenses are simply corporate write-offs and they provide the perquisites needed to retain high quality managers. In any event, the "Pub lunch" or "Club lunch" are very popular in England. Apart from possible violations of the "Standards of Conduct for Government Employees," or other corporate ethical standards, the English ale is quite potent and could inhibit a negotiator's level of efficiency in the afternoon sessions. All things considered, most American negotiators indicated they enjoyed negotiations with the British.

Netherlands. The Dutch seem to be extremely tolerant people and they sometimes describe themselves as "citizens of the World." They are excellent businessmen with many years of extensive trading experience. Most American negotiators described the Dutch as being punctual, literal, neat, and clean. At the negotiating table they are rather straight forward, not secretive like the French. Rather than being philosophical, the Dutch tend to be quite practical. They like to get things moving and finish the job as promptly as possible. In this

regard, the relationship between the American and Dutch negotiator seems to be less adversarial than the American and German relationship. Some American negotiators noted that the Dutch seem to really want to reach an agreement and do not require much prodding in order to make progress.

Because many Dutch are experienced traders, they are certainly not "push-overs" at the negotiating table. Most American negotiators agreed the Dutch were frequently persistent ("hard-headed") and would keep reopening discussion on any points they were not completely happy about. Still, the Dutch negotiator does tend to have more authority and flexibility than the German negotiator and, thus, negotiations tend to move along quite a bit faster. Like the Germans, the Dutch do caucus at the table (in Dutch) but do not seem to care if anyone listens to what they are talking about.

Based on the comments of the American negotiators interviewed during this study, it is clear that the U.S. government contract negotiator will face many new challenges in dealing with the Germans, French, British, and Dutch. The negotiator's degree of success in meeting these challenges depends upon his level of competence in modifying his successful domestic negotiation techniques in order to account for cultural influences on the negotiation process. As to the appropriate means of helping the negotiator achieve success, a few suggestions are presented in the summary.

SUMMARY

Negotiation is truly an art rather than a science. While examples are useful in illustrating how cultural factors influence the negotiation process, any conclusions should clearly recognize that individual personalities might not be consistent with these general conclusions. The astute negotiator should be aware of cultural influences but must always be alert to the specific behavior and personality of his counterpart across the negotiating table.

Assuming that no major organizational changes will be forthcoming to improve DOD's ability to negotiate effectively overseas, then some means should be sought to improve the existing purchasing office's ability to conduct these negotiations. In this regard, it might be useful to hold mock negotiation sessions with a small cadre of personnel who are experts in negotiating with various foreign countries. These "murder board" sessions hopefully would permit the American contract negotiator to get some exposure to the foreign environment in which he will be negotiating.

It would be ideal if the chief negotiator could speak the foreign language. Although negotiations would still be conducted in English, since English generally would be the language spoken by the majority of the participants, the chief negotiator would be able to learn a great deal from the "table talk" during negotiations. This recommendation is not intended to suggest that the chief negotiator pretend not to understand the foreign language. On the contrary, his knowledge of the foreign language (and customs) would be a giant step forward in fostering mutual trust. Even though the table caucuses will be a bit less open, the habit of presuming that Americans do not understand will take a long time to break.

Based on the interviews and literature search, the following recommendations are provided to summarize some of the important aspects of preparation for negotiation overseas:

(1) Recognize that the motivation of foreign governmental agencies and firms will probably be different from that which is found in the United States.

(2) Recognize that the relationship and degree of control of the foreign government over the foreign firm might influence negotiations. Employment goals, collective bargaining restrictions, and profit goals may vary considerably from country to country.

(3) Pre-staff objectives to the maximum extent possible so that anticipated compromises are approved prior to negotiations.

(4) Very "thorny" issues should be deferred and then reintroduced after enough earlier agreements set the stage for easier resolution.

(5) Besides these special aspects, all normal negotiation preparations (e.g., strategy and tactics) should be carefully thought out well in advance of negotiations.

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CURRENT OBSERVATIONS ON FMS

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ABSTRACT

Foreign Military Sales (FMS) are a large part of the dynamic systems acquisition environment in the Department of Defense and Industry today. President Carter announced in January 1980, a major policy reversal of his conventional arms transfer constraint, restricting FMS to weapons designed for US Forces, to permitting US Defense Contractors to design and build military aircraft expressly for export to foreign countries. Also covered is the interrelationship of DOD management techniques utilized in decision-making during the defense system acquisition life cycle, the resource allocation funding cycle, and the organization, documentation, and procedures of foreign military sales approvals and implementation.

CURRENT OBSERVATIONS

Conventional Arms Transfer Policy. The major provisions of President Carter's policy continue to remain in effect and include the following:

- The U.S. must restrain transfer of conventional arms.

- The U.S. will continue to promote the security of allies and close friends. The burden of persuasion will be on those who favor a particular sale, rather than on those who oppose it.

- Dollar restraints and other controls will not apply to NATO, Japan, Australia and New Zealand. The U.S. will remain faithful to treaty obligations, as well as to responsibilities regarding Israel's security.

- In formulating Security Assistance programs, the U.S. will promote human rights, and assess the economic impact of transfers.

- The dollar volume of new commitments under FMS and MAP for weapons and weapons-related items in FY'77 (in constant '76 dollars) will be reduced from the FY'77 total. (This decline has been extended into FY'80.) Services and commercial sales are excluded from the total.

- The U.S. will not be the first to introduce newly-developed advanced weapon systems into a region. No commitments for sale or co-production of such systems will be made until the system is operationally deployed with U.S. Forces. Development of such a system solely for export will not be permitted. (A major modification of this policy occurred in January 1980.)

- Agreements for co-production of significant weapons, equipment or major components will be limited to assembly of subcomponents and fabrication of high-turnover spare parts.

- In addition to existing requirements under the law, the U.S. may stipulate, as a condition of sale, that it will not entertain requests for retransfer to third countries.

- Department of State policy-level approval will be required for licensing of manufacturers; for sales promotion of arms abroad; and for U.S. military or civilian briefings which might promote sales. U.S. Embassies or military elements will not promote arms sales.

The President emphasized that his policy was not aimed exclusively at the volume of arms transfers. Equally important was restraint in the sophistication of the arms, and in the spreading capability to produce arms. The Carter Administration is now well into the fourth year of its policy of restraint on conventional arms transfers. Basic tenets of the policy are firmly in place, and are being implemented.

Initially, to ensure effectiveness, and to enforce controls, the Department of State established an advisory board, the Arms Export Control Board (AECB), chaired by the Under Secretary of State for Security Assistance, Science and Technology. General agencies are represented on the Board and the AECB has developed new interagency review and clearance procedures, and provided new guidelines to Industry and USG officials for dealing with foreign governments on matters of arms transfers. In addition, the AECB is responsible for developing the annual Security Assistance Budget and for setting up procedures for reporting to Congress, as required by law. The AECB is discussed in more detail later in this paper. In keeping with emphasis on human rights, an Assistant Secretary of State for Human Rights and Humanitarian Affairs also has been designated.

President Carter's pledge to restrain conventional arms transfers was announced in a speech on 19 May 1977. Presidential policy of restraint on transfers of all weapons and weapons-related items for FY'79

required the dollar value of all new orders which were FMS and Military Assistance Programs (MAP) to be less than the FY'78 total of $8.551 billion (measured in FY'76 dollars) by eight percent. This reduction meant that, for FY'79, new commitments for weapons and weapons-related items made under FMS and MAP to all countries (with the exception of NATO, Japan, Australia and New Zealand), when adjusted for inflation would not exceed $8.43 billion. The FY'80 arms transfer ceiling has not been stated at this writing however, an additional reduction of eight percent from the FY'79 ceiling is expected. At the end of FY'78, the U.S. had a backlog of undelivered FMS approaching $43.5 billion. One year later, in CY 1979, despite termination of some $7 billion of sales to Iran, the FMS backlog still exceeded $40 billion for approximately eighty countries and International Organizations.

U.S. Policy on Sales Promotion

• All DOD personnel have been and are instructed to refrain from encouraging or promoting sales, except in those cases where such activities are specifically authorized after careful deliberation by senior USG officials. (Example: the sales promotion of F16s to a officials. (Example: the sales promotion of F16s to a consortium.)

• Restraints on sales promotion had not applied to commercial marketing activities overseas. However, the USG will now be aware of all significant defense marketing actions overseas by U.S. defense manufacturers. Marketing activities in NATO, Australia, New Zealand and Japan will not require policy-level authorization by State.

• Major deterrants to promotion are: the policy of restraint and the U.S. interagency review process, culminating in a review of all major sales by the Arms Export Control Board and by the President, personally.

• Fees for the use of Government-owned equipment by contractors engaged in foreign sales are required, and controls over agents' fees have been established.

Department of Defense

• The Office of the Secretary of Defense has established procedures for managing a ceiling on weapons and weapons-related items only. This annual ceiling does not apply to NATO countries/agencies, Japan, Australia and New Zealand.

• The Defense Security Assistance Agency (DSAA) is responsible for implementation of the procedures. DSAA has compiled two separate lists of items --those that are weapons, and those that are not. The agency has developed an allocated accounting system to provide positive controls to assure that sales of weapons and weapons-related items do not exceed the annual ceiling established by President Carter. The DSAA Ceiling Management Division is responsible for maintaining the allocation accounting system.

• Congress requires an annual report (by 15 November) of all arms transfers that the Executive Branch "considers eligible" for submittal to Congress during the fiscal year. The Under Secretary of State for Security Assistance, Science and Technology states:

> "...the Administration will establish priorities, within the...ceiling. These will be based on the security needs of the requester, the political and military importance the United States and the requester each attach to the transfer, the potential impact on the region, human rights, economic impact, arms control considerations and relevant technical elements... such things as equipment availability, the potential for compromise of sensitive technology, and the capacity of the recipient to absorb and maintain the equipment. ...quite reasonable conditions to put on arms exports...long part of the arms transfer decision process, but because they are now explicit elements of a public policy, they come into sharper focus."

Legislative Changes for FY'80. The International Security Assistance Act, enacted in October of 1979, amended the Foreign Assistance Act of 1961 (FAA), and the Arms Export Control Act of 1976 (AECA). Pertinent provisions of this legislation are described below.

• Foreign Military Sales credits authorized are $673.5 million, to fund a $2.234 million program for FY'80.

• The President is authorized to use the special authority set forth in FAA, Section 506, to "draw down" up to $10 million in Department of Defense stocks (in emergencies), upon prior notification to the Committee on Foreign Affairs of the House of Representatives; the Committee on Foreign Relations of the Senate; and the Committees on Appropriations of each House of the Congress.

• Stockpiling of defense articles for Foreign Governments is authorized to $95 million for FY'80.

• Section 542 of the Foreign Assistance Act of 1961 is amended to authorize $31.8 million for grant military education and training programs.

• Cooperative cross-servicing and lead-nation procurement arrangements of U.S.-supplied defense articles or services among NATO members, and between NATO and its members, are exempted from constraints, provided that certification transmitted to Congress (AECA, Section 36(b)) identifies the transferees on whose behalf the lead-nation procurement was proposed.

• The President is authorized to reduce or waive administrative or other charges, and also to waive the requirements for sales made and licenses issued in furtherance of NATO cooperative projects. (AECA, Secs. 36(b) and (c).)

- Make "weapons or weapons-related defense equipment," rather than "defense equipment" and "defense articles or defense services," the subject of the annual report to Congress; to require that "sales deemed most likely" to result in the issuance of a Letter of Offer during the next fiscal year be appropriately identified in the annual report to Congress; and to require Presidential notification, every six months, concerning changes in the arms proposal provided in the annual report to Congress, together with the reasons therefore.

- To require a classified report at the time of the annual arms sales proposals, detailing the best estimates on the international volume of arms traffic, including annual estimates of sales and deliveries during the succeeding three (3) years.

- The President shall undertake a thorough review of the interagency procedures and disclosure criteria used by the U.S. in determining whether sensitive weapon technology will be transferred to other countries. Not later than 15 February 1980, the President shall transmit a report to Congress setting forth the results of such a review, together with such recommendations as are necessary to improve the current disclosure system. AECA, Section 36(b)(1) is amended to read, "such numbered certifications shall also contain an item, classified if necessary, identifying the sensitivity of technology contained in the defense articles or defense services proposed to be sold."

- The ceiling on commercial arms sales, AECA, Section 38(b)(3), is amended to be $35 million --instead of $25 million.

- The President shall exercise restraint in selling defense articles and services, and in providing financing for sales of defense articles and services to countries in Sub-Saharan Africa.

- A new quarterly report to Congress: listing Price and Availability (P&A) estimates provided to Foreign Governments, with respect to major sales; and listing requests received from foreign countries for issuance of Letters of Offer, if the proposed sales are not subject to the above listing. Issuance of these Letters of Offer would be subject to the requirements of AECA, Section 36(b).

- It is the sense of the Congress that the President maintains adherence to a policy of restraint in conventional arms transfers. In implementing U.S. policy on conventional arms transfers, a balanced approach should be taken, and full regard given to U.S. security interests in all regions of the world.

World events continue to impact on the economic and political factors which create the dynamic climate of FMS. In addition to commercial sales of defense articles and services, over $13 billion of FMS were transacted in 1978, and over $15 billion in 1979. The upward trend is likely to continue in 1980, encouraged by a major reversal in President Carter's policy of restraint for conventional arms transfer. Policy in 1977 restricted foreign arms sales to weapons designed for U.S forces. The new policy, announced by the State Department in January 1980, would permit U.S. defense contractors to design and build military aircraft expressly for export to foreign countries.

It is apparent that the force of world events has already pressed heavily against the policy of restraint for conventional arms transfer. Government and Industry must remain sensitive, keep well-informed and continue to adjust to the ramifications of that pressure.

MAJOR DOD MANAGEMENT SYSTEMS

There are three major acquisition management systems in the Department of Defense:

1. Management of specific major defense systems acquisition.

2. Resource allocation (Planning, Programming, Budgeting System, PPBS).

3. Foreign Military Sales.

The management of specific defense systems acquisition today is in accordance with the Department of Defense (DOD) policy promulgated by Department of Defense Directive (DODD) 5000.1, "Major Systems Acquisition" and DODD 5000.2, "Major Systems Acquisition Process."

It is the responsibility of the military departments (DOD components) for a "continuing analysis of mission areas to identify needs and to define, develop, produce and deploy systems to satisfy those needs," (ref. DODD 5000.1). The documentation used to identify the need and initiate programs, are the Statement of Operational Needs (SON) for the U.S. Air Force, Operational Requirements (OR) for the U.S. Navy and the Requirement for Operational Capability (ROC) for the U.S. Army. A special requirements document for major programs in the Department of Defense is the Mission Element Need Statement (MENS), usually a spin-off of the DOD components requirements document. Program initiation and development of the system over its acquisition life cycle for less-than-major programs is the responsibility of the DOD components and a function of their priorities and funds available. Approval for a Major Program initiation is a responsibility of the Secretary of Defense and titled Milestone Zero (M-0). The responsibility for the development and management of a defense system acquisition during its acquisition life cycle rests with the DOD component. The Milestone I - Demonstration and Validation, Milestone II - Full-Scale Engineering Development, Milestone III -Production-Deployment (with the supporting Decision Coordinating Paper (DCP) documentation) decisions for major systems are the responsibility of the Secretary of Defense (SECDEF). The Office of the Secretary of Defense (OSD) level recommending body, the Defense Systems Acquisition Review Council (DSARC) reviews the program status and makes a recommendation to the SECDEF at each Milestone decision (except M-O).

The second management system; resource allocation in the DOD, is the Planning, Programming and Budgeting System (PPBS). This calendar-oriented system correlates the National Objectives, the strategy developed by the Joint Chiefs of Staff (JCS), the force levels and support required to carry out the strategy, with the funding levels necessary to develop, operate and maintain them over a five year time period. The output of this management system is the annual DOD budget input to the Federal budget to Congress.

The specific program management system, utilizing the milestone decision points and DCP, is an event-oriented system that interfaces with the calendar-oriented PPBS system in the DOD component (Military Services and Agencies) input document called the Program Objectives Memorandum (POM). The POM is the DOD component's position reflecting the fiscal and force level guidance provided by the OSD. The program manager's funding requirements must be included in the POM for him to implement his responsibilities to manage the development and production of his system.

The documentation, organization and procedures for foreign military sales (FMS) approvals and implementation constitute the third management system that a program manager must interface with.

Foreign Military Sales Policy and Guidelines. Current FMS policy and guidelines are predicated on the Arms Export Control Act of 1976, which became law on 30 June 1976. This act was the result of amending the Foreign Assistance Act of 1961 and the Foreign Military Sales Act of 1968. Congress also renamed the FMS Act, calling it the Arms Export Control Act (AECA). Congress stated its basic policy in this statement included in the amending legislation; International Security Assistance and Arms Export Control Act of 1976:

> It shall be the policy of the United States to exert leadership in the world community to bring about arrangements for reducing the international trade in implements of war and to lessen the danger of outbreak of regional conflict and the burdens of armaments. United States programs for or procedures governing the export, sale, and grant of defense services for foreign countries and international organizations shall be administered in a manner which will carry out this policy.

Further, a major change in the "sense" of the Congress, in the 1976 law, is a reversal of the previous policy of encouraging Direct (Commercial) Sales in favor of FMS, and thereby increasing Congressional control of military material and services through reporting and approval constraints.

Congressional approval of all Foreign Military Sales is contingent on that sale being:

- consistent with U.S. foreign policy;
- within the purposes of the Foreign Assistance Act;
- within the cash or credit economic capability of the Foreign Government;
- in proper balance with the Military Assistance Program and U.S. economic assistance; and
- a positive impact on social and development programs and a negative impact on incipient arms races.

The Arms Export Control Act establishes the broad guidelines under which the FMS program is to be administered, and also assigns specific management responsibilities:

- The President shall determine the foreign governments' eligibility to purchase defense articles or services;
- The Secretary of State, under direction of the President, is "responsible for continuous supervision and general direction of sales, including, but not limited to, determining whether there shall be a sale to a country and the amount thereof, to the end that sales are integrated with other United States activities and the foreign policy of the U.S. is best served thereby;" and
- The Secretary of Defense, under direction of the President, is responsible for:

  - determination of military end-item requirements;
  - procurement of military equipment in a manner which permits its integration with Service programs;
  - supervision of training of foreign military personnel;
  - end-item movement and delivery; and
  - establishment of priorities in the procurement, delivery and allocation of military equipment.

USG Organization for FMS. The President has the responsibility to determine foreign governments' eligibility to purchase defense articles and services, and provides reports to Congress and standing committees concerned with FMS. (See Figure 1.) The Office of Management and Budget (OMB) reports to the President; the International Affairs Division is responsible for FMS activity. The National Security Council (NSC) advises the President concerning FMS policy. The Secretary of State, Department of State, reports to the President concerning FMS responsibilities that have been delegated, and effects coordination with the responsibilities of the Secretary of Defense, Department of Defense.

The Arms Export Control Board (AECB). The Arms Export Control Board (AECB) was established in order to aid in the implementation of International Security Assistance and Arms Export Control Act of 1976. The purpose of the board is to advise the Secretary of State, National Security Council and President in matters relating to conventional arms transfers. The board functions in an advisory, not decision-making

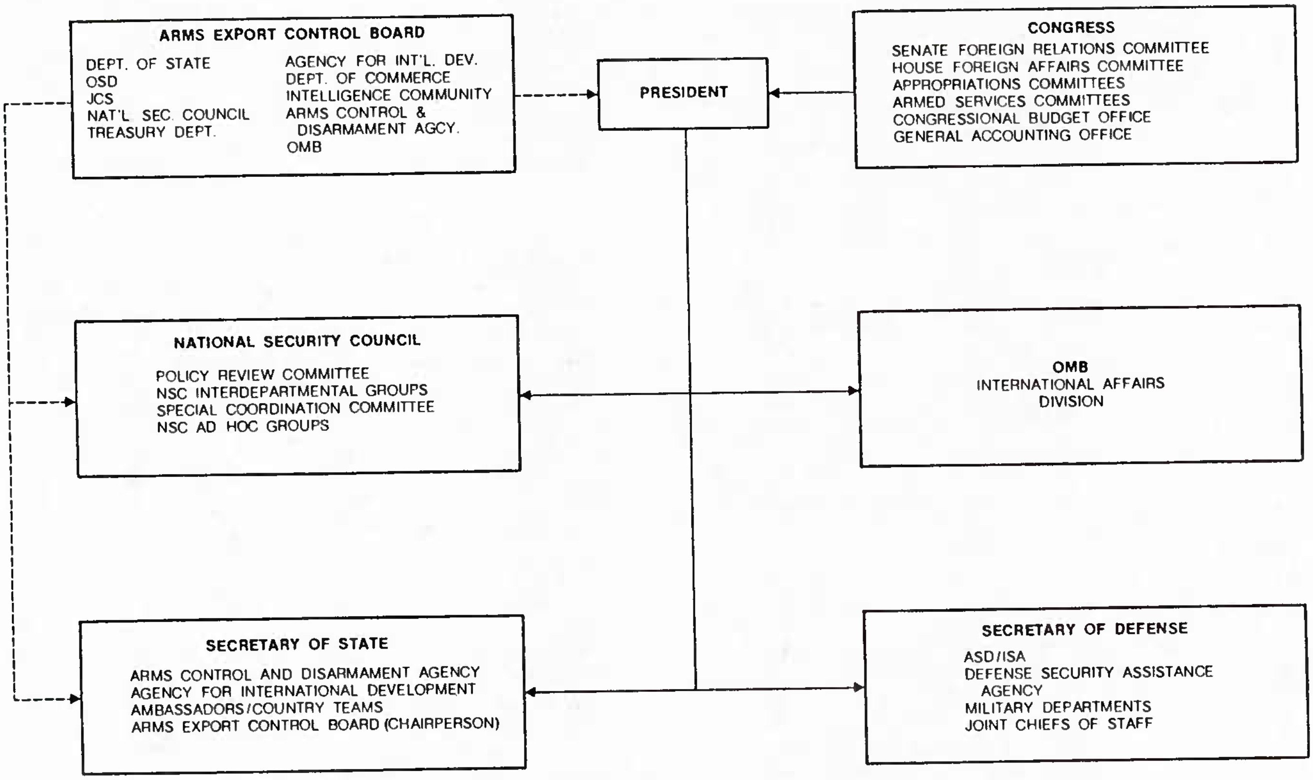

Figure 1. U.S. Government Organization For FMS

capacity. It is composed of senior representatives from the Department of State, the Office of the Secretary of Defense, the Joint Chiefs of Staff, the National Security Council, the Arms Control and Disarmament Ageny, the Treasury Department, Office of Management and Budget, the Agency for International Development, the Commerce Department and the Intelligence community. The Under Secretary of State for Security Assistance, Science and Technology, serves as chairperson.

The AECB provides recommendations in the following specific functional areas:

- Provision of systematic and comprehensive policy oversight in the arms transfer field.

- Review of security assistance plans and programs to ensure that they support overall U.S. policies and are fully coordinated with other policy instruments. Such reviews specifically include human rights and arms control considerations.

- Preparation of annual program funding levels and budget submittals and consideration of proposed program changes.

- Establishment of general policy guidelines and criteria for arms transfers and related activities such as co-production, technology transfer, third-country transfers, and export promotion policy.

- Selective review of key transfers of defense articles and services to ensure they are in accord with overall U.S. policies.

Congressional Role in FMS. Congress, in its role as the Legislative Branch of the U.S. Government, controller of the purse, and in its oversight function, has laid down specific rules and guidelines for the conduct of Security Assistance and Foreign Military Sales. The International Security Assistance and Arms Export Control Act (AECA) of 1976, as passed by Congress, encompasses the basic rules and guidelines under which Congress wants foreign military sales conducted. (See Figure 1.) The AECA is amended each year to reflect Congressional concerns and policy (i.e., amount(s) of FMS credits or other restrictions).

Some of the key constraints required by law are:

1. The President shall submit to Congress quarterly reports, country-by-country, including:

- listing all LOAs to sell any major defense equipment for $1 million or more;

- the total value of all LOAs that have been accepted;

- cumulative dollar amounts, by country, of sales credit and guaranty agreements;

• listing all licenses and approvals for export, by country, and major defense equipment sold, by category, for $1 million or more;

• projections of cash sales and credits, by quarter and the remainder of the fiscal year;

• estimated number of offices, government employees and civilian contract personnel in each country for assignments of sales and commercial export implementation.

• an analysis and description of services being performed by officers and government employees; and

• certification, 30 days in advance, of licenses of commercial sales of defense equipment over $7 million, and of other commercial sales of articles and services over $35 million.

2. Congress has thirty calendar days to object, by concurrent resolution, to those FMS of major defense equipment of $7 million and over, as well as all FMS over $35 million.

3. Use of commercial channels (Direct Sales) for major defense equipment sales of over $35 million or over, except to NATO countries, is prohibited.

4. No security assistance can be provided to any country which engages in a "constant pattern of gross violations of internationally recognized human rights."

5. Within sixty days of receiving information substantiating that an official(s) of an FG receiving security assistance has (have): 1) received illegal or otherwise improper payments from a U.S. corporation in return for a contract or, 2) extorted or attempted to extort money or other things of value in return for actions by that official of that country that permit a U.S. citizen or corporation to conduct business in that country, the President shall outline the circumstances for Congress and recommend whether or not security assistance should be continued.

The Security Assistance programs, of which Foreign Military Sales are a part, are reviewed by Congress in two ways:

• annual review and amendments to the Foreign Assistance Act of 1961, and the Foreign Military Sales Act of 1968 (now the Arms Export Control Act), and

• the Security Assistance portion of the DOD/Federal Budget.

Congressional concerns and policies regarding Foreign Military Sales are expressed in the annual amendments adopted and the funds provided to support the Security Assistance Program.

The standing committees in Congress that are concerned with review of the Security Assistance programs, recommending amendments and authorization and appropriation levels, are:

• Senate Foreign Relations Committee

• House Foreign Affairs Committee

• House and Senate Budget Committee

• House and Senate Armed Services Committee

• House and Senate Appropriations Committee

Data and information concerning Security Assistance progams is presented annually to Congress in the Congressional Presentation Document. It is prepared by the Department of Defense, in coordination with the Department of State. This document is a detailed, unclassified country-by-country justification of Security Assistance programs proposed by the Administration. The Congressional Presentation Document is supplemented by a classified document, "Security Assistance Review," which provides additional data and justification. Another source of information available to Congress upon which it can base decisions concerning legislation is the testimony of witnesses from the Departments of Defense and State.

DEPARTMENT OF STATE ROLE IN FMS

Foreign Military Sales, as a part of the Security Assistance Program, support the foreign policy and security objectives of the United States. Sales have, in the past, improved foreign countries internal order and increased the prospects for regional stability, thereby reducing the likelihood of direct U.S. military involvement.

In the Executive branch of the U.S. Government, the Department of State has primary responsibility, under the direction of the President, for implementing foreign policy (see Figure 1). The authority and responsibility of the Secretary of State, Department of State, in matters of foreign policy is stated explicitly in the Arms Export Control Act, and Executive Order 11501. The authority of the Secretary of State includes approval authority for all military sales.

Foreign Military Sales. Extension liaison is maintained between the Department of State and the Department of Defense to ensure the coordination of U.S. political, military and economic objectives. Within the Department of State, a political-military board, chaired by the Under Secretary of State for Security Assistance, Science and Technology, meets regularly to discuss foreign military sales. Major sales are weighed for their foreign policy implications. Congressional interests must also be considered. (e.g., in the recent past, sale of Hawks to Jordan was questioned and the quantities of Sidewinders and Maverick missiles for Saudi Arabia were reduced.)

Direct Sales. The Department of State is involved in the approval of commercial sales of military material through its Office of Munitions Control. The Office of Munitions Control is responsible for the issuance of licenses to U.S. contractors requesting approval to export major defense equipment or munitions list items or related technical assistance. The major defense equipment list or munitions list is a

categorized list of items ranging from rifles, ammunition, artillery, bombs, missiles, aircraft, fire control systems, and military training, to auxiliary equipment and technical data related to these items. A U.S. contractor or manufacturing firm applies to the State Department for an export license under one of the munitions control categories and then the request is processed through other appropriate Executive Departments or Agencies (i.e., Defense, Commerce, Treasury, et al.) for comment.

Additional areas that require a license are: technical assistance agreements, technical briefings, (such as those exhibitions at trade fairs held overseas) or a temporary license to take a demonstration prototype to show to a potential customer.

The Office of Munitions Control coordinates the requests for export licenses with other interested government agencies; however, in the Department of Defense, the Office of the Assistant Secretary of Defense (International Security Affairs) is the office that conducts the coordination with the particular military department or Department of Defense agency having a particular interest or cognizance in the system or material involved. The relationship or potential impact on the national security policies, objectives and plans will determine the extent of the coordination and review necessary within the Department of Defense. The International Traffic in Arms Regulation (ITAR) is a control mechanism designed to ensure against indiscriminate sales by U.S. contractors and manufacturers without regard for overall U.S. policy and interests.

DEPARTMENT OF DEFENSE ROLE IN FMS

In the Foreign Military Sales Program, the Department of Defense is the primary agency that implements the sale. Its scope or responsibilities include:

- Assisting the customer in determining its requirements as related to a specific system or support.
- Contracting for the weapon system development, production and delivery to the FG.
- Providing training, construction and logistical support.
- Collecting the purchase price from the FG and paying the contractor.
- Management of the contract.
- Sale of defense articles and defense services from stocks of DOD.

In carrying out its responsibilities the DOD provides pricing, production scheduling, and delivery details to eligible FGs, on approval of the sale by the Department of State, and determination that the sale will be in the national interest of the U.S. After the request for purchase has been approved, usually based upon an inquiry from an FG, for Price and Availability (P&A) of a defense system or services, the DOD responds to the request by the issuance of a Letter of Offer (LOA) -- (a Letter of Offer becomes a Letter of Offer and Acceptance on signature by the FG). In addition, the law provides that for orders of $7 million or more and less than $35 million for major defense equipment (for a specific list of categories of material, see Appendix A), DOD submits the proposed sale in Congress for review. All orders of $35 million, or more, must be transacted as FMS.

Details of pricing, contracting, production, delivery and follow-up support are generally the responsibility of whatever Military Department (Army-Navy-Air Force) has cognizance of particular material, system or service involved, and the industry or industries that will actually produce the equipment.

The Military Departments' functional activities conducted in the implementation of the FMS include: preparation of data necessary for program planning and budgeting; advice and recommendations on program modifications; procurement and delivery of materials; inclusion of equipment and services in approved programs; preparation of the P&A and actual LOAs for the military sales cases; and coordination and implementation of actions necessary to accomplish delivery of end items; related training; and logistic support.

For products such as uniforms, boots, helmets, etc., the Defense Logistics Agency (DLA) and other agencies of the U.S. Government are the primary sources for this type of FMS. The DLA also has a responsibility for the disposition, through sale, of excess military equipments. The disposal program is operated through DLA's Defense Property Disposal Service, Battle Creek, Michigan.

Over the years, the Military Departments developed their own systems to manage the rather low level of FMS. Most of the sales involved single-Service systems and, as a result, the internal policy of management practices and procedures were different. In recent years, and principally since the marked increase in FMS, the requirement for inter-Service integration has also increased because of the composition of many of the systems, e.g., critical subsystems being supplied by different Services --Navy engine or missile for an Air Force airframe. The necessary support for the total system therefore being supplied by different Services. The multi-Service coordination and liaison required in this type of FMS is receiving increased attention in terms of standardization of procedures and management problems and for improved customer service.

<u>Office of the Secretary of Defense Organization for FMS.</u> As shown in Figure 2, the Assistant Secretary of Defense, International Security Affairs (ASD/ISA) is the principal staff assistant to the Secretary of Defense in the functional field of International Security which encompasses Foreign Military Sales. ASD/ISA formulates policy, and represents the Department of Defense with other agencies in matters which concern Security Assistance, policy and guidance. The Defense Security Assistance Agency (DSAA) reports to the Assistant Secretary of Defense, International Security Affairs (ASD/ISA) who carries

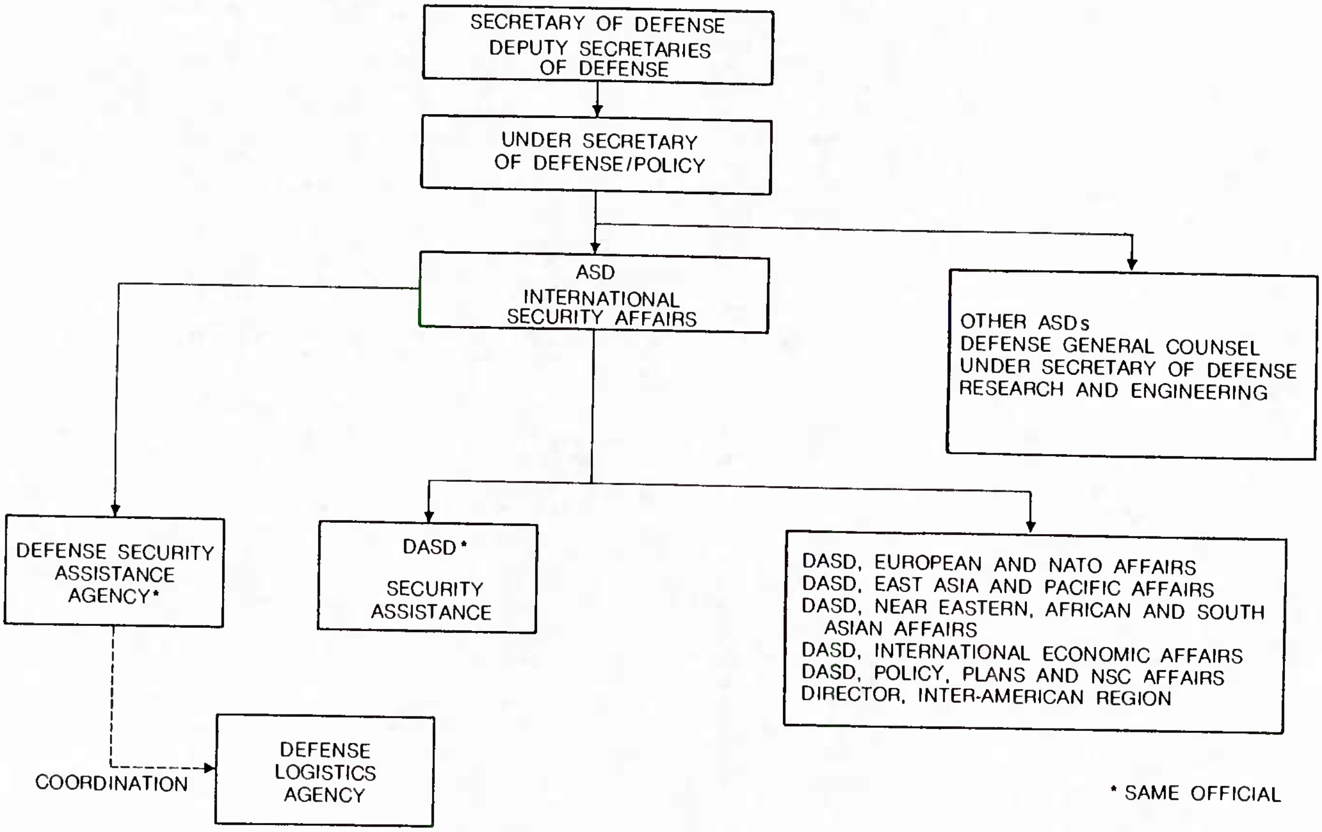

Figure 2. OSD Organization For FMS

the responsibilities of the Secretary of Defense under the Arms Export Control Act of 1976, and the executive orders and directives relating to the administration of military assistance and foreign military sales.

The Deputy Assistant Secretary of Defense/Security Assistance (who is double-hatted as DSAA) is responsible for developing plans and requirements relating to FMS, and as DSAA, is responsible for the implementation and monitoring of approved programs through the military departments and agencies within the Department of Defense.

The Assistant Secretary of Defense, International Security Affairs (ASD/ISA) retains, at his level, final decision authority for development and implementation of FMS policy. ASD/ISA reports to the Secretary of Defense through the Under Secretary of Defense for Policy, and the Deputy Secretary of Defense.

In accordance with ASD/ISA guidelines, DSAA acts as FMS action/coordination/implementation group for ASD/ISA. In this role, DSAA handles all FMS matters for the Secretary of Defense, coordinating with multiple offices; passing recommendations to, and implementing actions approved by, ASD/ISA or an authority at a higher level.

Frequent internal coordination takes place within the ASD/ISA Regional; Planning and Policy; Legal; and International Economic Affairs Offices. The Department of State also conducts internal coordination between its Regional and Political-Military Offices. Within the Office of the Joint Chiefs of Staff, the Regional and Policy Offices coordinate.

Coordination with OSD is expanded, when necessary, to include Research and Engineering (OUSDR&E); Munitions Control; Industrial Security; Comptroller; and Legislative Affairs Offices.

Corresponding Offices within the Military Service(s) (e.g., R&E, Technology Control and Comptroller), may also be asked to provide comments on FMS issues during the coordination processes of DSAA, OSD, or JCS.

Organizational relationships of OSD, the Department of State, the Joint Chiefs of Staff (JCS), Unified Commanders, Military Assistance and Advisory Groups (MAAGs) and the Military Departments are shown in Figure 3. The Assistant Secretary of Defense, Manpower, Reserve Affairs and Logistics (ASD/MRA&L), is responsible for developing delivery policy for the movement of MAP and FMS. Implementation of delivery policy is accomplished by the Military Service(s) and DOD Agency(ies).

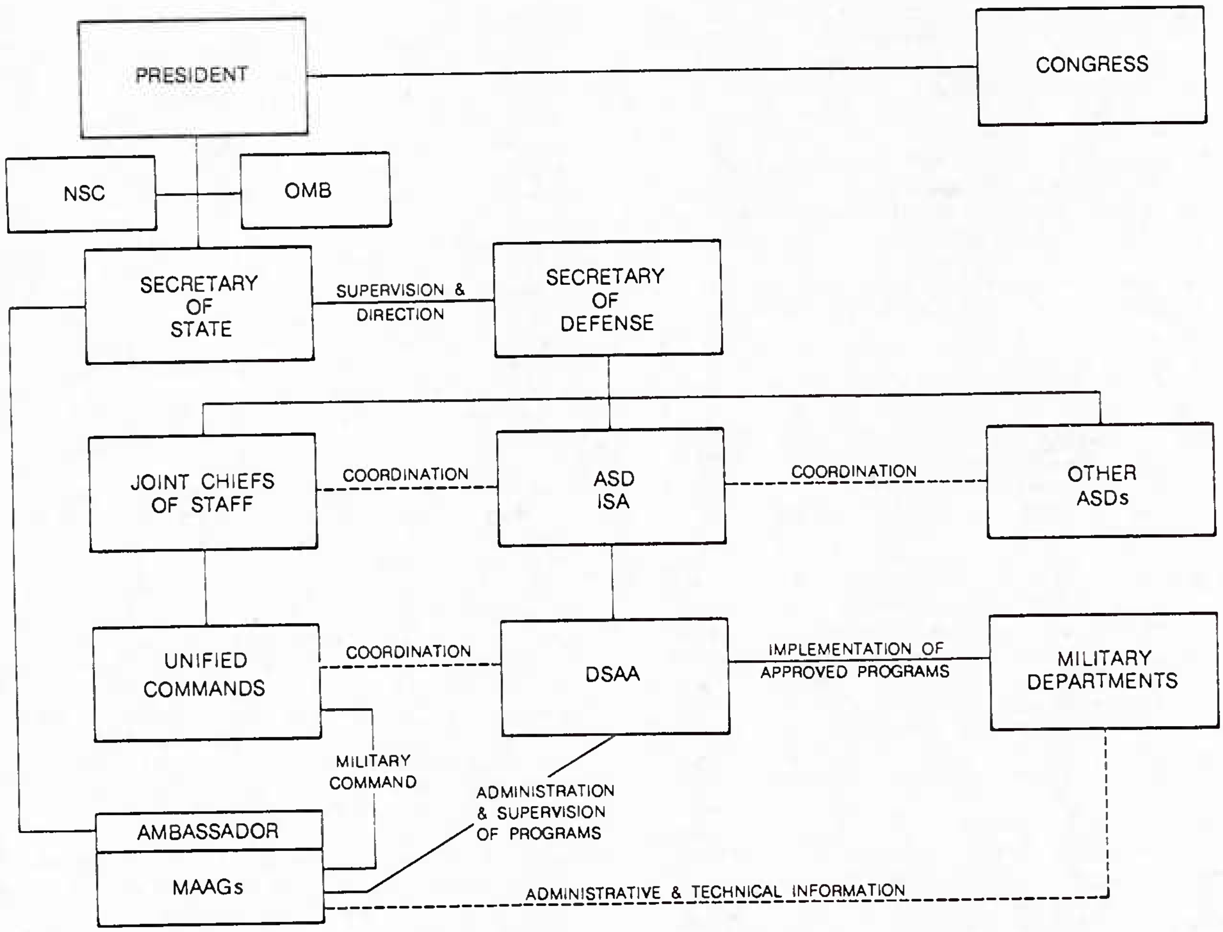

Figure 3. DOD Direction and Coordination for Security Assistance

FOREIGN MILITARY SALES CASES

Standard Sales. Standard sales are normally hardware end-items and provisional spare parts, necessary to meet a specific need. Also sales of defense articles and services to eligible foreign governments and international organizations on a one-time basis. The sale is documented on the Letter of Offer and Acceptance Form (DD-1513).

Blanket Order Sales. The principal advantage of Blanket Order (also called Blanket Open- End (BOE)) Sales which are open-ended requisition cases, is a reduction in the number of cases that would otherwise be needed to fill small or intermediate requirements. The Blanket Order FMS case is an agreement between an Foreign Government (FG) and the United States Government (USG) for a specific category of items or services (including training), but with no definitive listing of items or quantities. Each case is delineated in terms of dollars only, expressing the customer-country's estimated annual consumption of repair or spare parts. The case may specify the end-items or system to which the support or components apply, or it may be without specific limitation.

Cooperative Logistics Sales. Continuing peacetime support is supplied to an eligible customer-country through its participation in the U.S. DOD Logistics System. The arrangements for the support are:

- Procedural arrangements between the USG and FG defense ministers, outlining the form and extent of the logistics support and the related terms and conditions.

- Implementing arrangements made at a military service-to-military service level which define the methods for implementation of the Procedural Arrangements.

SURCHARGES

Prices of defense articles and services sold to eligible FGs and international organizations (stated in P&A and LOA) include the following charges:

Assessorial Costs. These represent certain expenses incident to issues, sales, and transfers of material which are not included in the standard price or contract cost of material, such as:

• Packing, crating and handling costs: Costs (known as PCH&T costs, when transportation is included) incurred for labor, materials, or services in preparing the material for shipment from storage or distribution points.

• Transportation costs: Inland and ocean transportation costs, representing shipments by land, sea, and air, inland and coastal waterways, vessel or air, and including parcel post via surface or air.

• Port loading and unloading costs: Costs for labor, materials or services at ports of embarkation or debarkation.

• Prepositioning costs: Supply distribution costs incurred at locations outside the United States in anticipation of support to other authorized customers. These costs are applicable when shipments are made from overseas storage and distribution points, except that no prepositioning costs shall be assessed on "long supply" stocks.

Administrative Charges. Administrative charges for the use of the DOD logistics system are added to prices of contractual services and nonexcess material sold to eligible FGs and international organizations to recover the DOD costs. Such charges are made in lieu of separate computations of charges for the costs of general management and administrative expenses pertaining to supply and procurement and services, and other DOD costs which are difficult to isolate.

The rate charge for administrative costs is prescribed in DOD Instruction 2140.9, 9 March 1977. Supply Support Arrangements will include an administrative charge of 5 percent added to the basic sales prices of contractual services and/or material to be provided. Foreign Military Sales, other than Supply Support Arrangements, include an administrative charge of 3 percent added to the cost price of contractual services, new procurements, or material from stock to be provided.

Non-Recurring Cost Recovery. Recoupment of a pro rata share of nonrecurring development and production costs of product sales to FGs is required as outlined in DOD Directive 2140.2, 5 January 1977. The objective of this requirement is to insure that an FG pays a fair share of DOD R&D investment costs. The charge is to be included in the FMS or direct commercial sales price of the product or technology, unless reduced or waived.

In accordance with the provisions of DODD 2140.2, DOD military components are responsible for determining recoupment charges for all items of defense equipment having a total nonrecurring development and production cost of $5 million or more. Nonrecurring development and production costs are defined in DODD 2140.2 and DOD components are required to use actual, not program, cost data. However, estimates may be used where the development of more precise data is not possible.

Prior to applying pro rata recoupment charges to sales of items on the Major Defense Equipment List (MDEL), DOD components must insure that the proposed charge has been approved by the Director, DSAA. Approval will be requested only for those items: (a) which are on the latest edition of the MDEL, (b) for which there exists a current FMS or commercial sales demand, and (c) for which there has not been an approved nonrecurring costs pro rata charge established since 5 January 1977.

DOD Directive 2140.2, 5 January 1977 also requires that, in the case of direct commercial sales of eligible defense items to FGs, the U.S. contractor must collect and pay to the cognizant military component the appropriate nonrecurring cost recovery charge for the items being sold. Military Departments monitor and report the collection of these recoupments in order to insure that all appropriate payments are made to the DOD.

Reduction or waiver of charges for nonrecurring development and production costs may be requested by the DOD components, customers or defense contractors. These waivers and reductions will normally be approved when it is clearly in the best interest of the United States, gaining advantage for DOD or other U.S. Government agencies, or when it is necessary to satisfy the demonstrable right of the customer or manufacturer. Items on the MDEL are waived or reduced as specified in Section 21(e)(2) of the Arms Export Control Act, as amended. Further requests for waivers or reductions relating to product sales must be submitted to the Director, DSAA, in accordance with DODD 2140.2.

Sales of defense articles which involve the use of government-owned facilities must be priced to include a 4 percent asset use charge, in accordance with DOD Directive 2140.1. Sales of defense articles which involve the use of government-owned tooling must be priced to include a rental charge for the use of the government-owned tooling and equipment. Waivers of these charges can be made only in accordance with the provisions of DOD Directive 2140.1, for the asset use charge, and ASPR 13-406 for the rental of government-owned tooling and equipment.

The Secretary of Defense, in a 14 December 1976 Memorandum, prescribed policies and procedures for allocating defense material and services between U.S. forces and international requirements.

The Military Departments, under normal circumstances, will fill Security Assistance material requirements from production, utilizing normal production lead times, unless DOD can meet such material requirements from inventory without an undesirable effect on the combat readiness of U.S. forces.

SUMMARY

A program manager's primary responsibility is to manage the development and production of a defense system to meet the military needs of his Service. In carrying out his responsibilities he must develop an acquisition strategy to assure viable alternatives, competition; planning and implementation of test and evaluation, ILS, procurement, training cost, schedule

and performance, the reduction of risk, etc., and meet his Initial Operational Capability (IOC). The program manager must also interface with the Planning, Programming and Budgeting System for the funding of his system acquisition and periodically re-structure his acquisition strategy to reflect changes in his program, re-direction and decisions made by his Service hierarchy and Congress.

The imposition of an FMS on his program can, and usually does, have profound impacts on his program. These impacts can range from schedule changes resulting from increased production, (impact on IOC data), separate configurations, with resulting R&D and testing; financial management of separate accounting of funds, development of separate documentation and approval procedures, increased workloads without commensurate personnel increases. Some of the beneficial impacts on his program can be in terms of lower unit production costs, sharing of engineering charge proposals (ECPs), testing, improved logistic support, and recoupment of R&D to the U.S. Government. In summary the impacts of FMS on a program manager's efforts and his program can be a mixed bag; some positive and some negative from his perspective.

The dynamics and political sensitivity of FMS in todays acquisition environment will surely impact on a large portion of defense systems acquisition because of the magnitude of the trends and backlog of FMS activity in the DOD.

This paper has attempted to highlight some of the critical aspects of FMS and their relationship to the management of systems acquisition in the Department of Defense. It is imperative that the program managers in DOD and Industry be knowledgable of the three interrelated management systems in the DOD in order to function effectively in todays acquisition environment.

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THE STATE OF NATO ARMS COOPERATION: AN AGGREGATE VIEW

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ABSTRACT

In response to an increasing Soviet threat in Western Europe and to the expense of developing new weapons to counter that threat, the US embarked on a policy of NATO arms cooperation over five years ago. The purpose of the paper is to provide quantitative background on the current state of NATO arms trade with emphasis on the four major producers: France, the FRG, the UK, and the US. It is only with such background that one can understand the difficulty faced in achieving additional cooperation over the next few years. Points discussed are (1) the US dominance of NATO arms trade, (2) the importance to the other three major producers of (a) potential or lost arms sales to the smaller European countries and (b) of sales by these countries to the non-industrial countries of the world, and (3) the extent of cooperative development programs among the three major European producers. Increased cooperation will require major political and economic compromises on the part of the four powers, compromises that have not yet been made even after five years of effort on both sides of the Atlantic.

AN AGGREGATE VIEW OF ARMS BUDGETS, IMPORTS, EXPORTS, AND INDUSTRIAL ACTIVITY

Of the $64.6 billion total defense R&D and production in the Western developed countries, in 1978, the US was responsible for $40.8 billion. The US provided over 60 percent of the production ($30 out of $49.4 billion). Limiting ourselves to the countries of primary interest in this study--the US, France, FRG, and the UK--the US provided approximately 70 percent of both the $43.6 billion production and the $15 billion of research and development.

The production of these four countries was not just to arm NATO and other industrial Allies that face the USSR. Of the $43.6 billion in four power arms production, $11.8 billion went to the developing (non-industrial) countries of the world (Table 1). Thus, the R&D of the major producers provides the weapons not only for NATO and the other developed countries, but also for countries with different problems of defense and--perhaps more important--different capabilities to support sophisticated weapons.

We note--looking at the data for 1978--that the US and France equip their forces almost entirely (96 to nearly 100 percent) with domestic arms, the UK somewhat less (90 percent), and the FRG least, but still providing 83 percent of its equipment from domestic sources. Still using 1978 figures, the US and UK export about one-third of their production, 32 and 34 percent, respectively; the FRG exports only 20 percent; while France exports over half, 53 percent. Further, looking at the destination of exports, we find that 47 percent of the total French production goes to countries outside the industrialized West.

Table 1. Equipment Expenditures, Procurement by Source of Production and Sales by Customer for Western Industrial Countries, 1978 (Billions of Dollars)

Category	Four Powers						Other Western Industrial Allies (1)	Total Western Developed
		Major European						
	US	France	FRG	UK	Total	Total		
Equipment Expenditures								
Totel Procurement	20.6	2.7	3.0	3.8	9.5	30.1	6.6	36.7
R&D	10.8	1.6	0.9	1.7	4.2	15.0	0.2	15.2
TOTAL	31.4	4.3	3.9	5.5	13.7	45.1	6.8	51.9
Procurement by Source of Production								
Domestic	20.5	2.6	2.5	3.4	8.5	29.0	4.8	33.8
Imports								
US	n.e.	0.05	0.35	0.1	0.5	0.5	1.3	1.8
Europe	0.1	0.05	0.15	0.3	0.5	0.6	0.5	1.1
Totel Imports	0.1	0.1	0.5	0.4	1.0	1.1	1.8	2.9
TOTAL	20.6	2.7	3.0	3.8	9.5	30.1	6.6	36.7
Sales by Customer								
Own Forces	20.5	2.6	2.5	3.4	8.5	29.0	4.8	33.8
Exports								
Industrial Allies (1)	1.8	0.3	0.5	0.2	1.0	2.8	0.1	2.9
Non-Idustriel Countries	7.7	2.5	0.1	1.5	4.1	11.8	0.9	12.7
Totel Exports	9.4	2.8	0.6	1.7	5.1	14.6	1.0	15.6
TOTAL	30.0	5.4	3.1	5.1	13.6	43.6	5.8	49.4

Sources: References [9,10,14,15, and 20-29].

If we examine the split between production and R&D--not within the defense budget--but for the whole arms industry (including in-house R&D and production)--we find that all four countries are quite close: 22 to 26 percent of their work in R&D, rather than the range of 23 to 43 percent of their defense budgets in R&D. This may be happenstance, but it does suggest that to understand the purposes of the R&D programs in each country, one must examine the missions and requirements of the customers of those countries, not just the requirements of the country performing the R&D.

ARMS TRADE AND COOPERATION AMONG THE MAJOR PRODUCERS

The significant aspects of the NATO arms trade are the low level of such trade within NATO, the US dominance as a producer, developer and exporter

and, finally, the sporadic and limited nature of arms cooperation. It is from this base that any policy on arms cooperation must be built.

Looking first at the arms trade among the four powers from 1973-1977, the US delivered about $2.5 billion in arms to the other three major NATO arms producers and bought about $350 million worth (Table 2). But France, even more than the US, has been reluctant to buy arms abroad. Her trade with the other three powers was limited to $155 million in purchases, all from the US, and $430 million in sales, mostly to the Federal Republic of Germany (2).

Table 2. Arms Trade Between US and NATO Europe and Within NATO Europe, 1973-1977 (Millions of Dollars)

Importers	Exporters						
	US	Major European				Medium European (3)	Total Imports
		France	FRG	UK	Total		
US	--	0	30	320	350	25	375
Major European							
France	155	--	0	0	0	5	160
FRG	1,705	400	--	90	490	300	2,495
UK	600	30	0	--	30	20	650
TOTAL	2,460	430	0	90	520	325	3,305
Medium European	1,002	160	190	130	480	100	1,582
TOTAL EXPORTS	3,462	590	220	540	1,350	450	5,262

Source: Reference [2].

The Federal Republic of Germany and the United Kingdom, on the other hand, have been willing to buy weapons from abroad that they could not or would not develop. However, the FRG purchases from the US and the UK have--from the mid-1960s until 1977--been made under an agreement by which the Germans agreed to offset foreign exchange losses for troops stationed in Germany. Without these agreements, it seems likely that German purchases would have been lower and would have involved more coproduction and licensing arrangements under which the Germans would have bought US designs rather than US equipment (4).

US-European Trade. Moving to the issue of arms trade between each of the four powers and other NATO countries, we find the US dominating the trade with five other NATO countries that purchase substantial arms with their own funds. The US delivered $1 billion in arms to those countries compared to $480 million in sales by France, FRG, and UK to those same countries. Thus, the one way traffic across the Atlantic so often complained about by France and the UK is largely between the US and the five other European countries.

Examining recent sales--rather than delivery data as above--we see, in Table 3, $6 billion in US sales to the same five countries. Thus, US arms deliveries to the smaller countries will show a substantial increase over the next few years, due

Table 3. US Arms Sales Agreements With Medium European Powers (Millions of Dollars) (7)

	1975-1979	Total 1955-1979	1975-1979 As a Percent of Total
Belgium	1,604	1,770	91
Denmark	929	1,068	87
Italy	131	794	16
Netherlands	2,206	2,426	91
Norway	1,372	1,651	83
TOTAL	6,242	7,709	81

Source: Reference [17, pp.1-2].

largely to the sales of the F-16 fighter aircraft to Belgium, Denmark, the Netherlands, and Norway. This US dominance will continue for a number of years due not only to the procurement of the F-16 but also to purchase of NATO early warning aircraft (AWACS) from the US (5).

US developed arms have dominated NATO arms transfers (6) since World War II. The early transfers were almost entirely aid--$12 billion worth through 1960 to the eight major buyers of arms we are discussing. Since then, the transfers have been largely sales. The largest transactions have occurred as part of coproduction agreements for US designed equipment. Through 1975 sales deliveries were about $12 billion, with another $5.5 billion in European coproduction of US designed systems [12, pp. 19-23] and [17, pp. 5 and 14] (8).

US domination has not been limited to the arms market. In a civil industry that is close to armaments in terms of technology, the civil aerospace industry, US dominance is greater than in arms (Table 4). For example, at the end of 1976 almost all the long range civil fleet both of the US and of the rest of the non-communist countries outside the common market was made up of US designed aircraft. Indeed, the worldwide figure for US designed aircraft, is 97.5 percent and would have been 100 percent if not for the Concord supersonic transport, which has gone out of production and out of business with 4 of 14 aircraft still unsold [5]. For short and medium range aircraft, 95 percent of the US fleet is US designed and 87.3 percent of the worldwide fleet is US designed. The US share for short and medium range aircraft fleets has decreased since 1976 as more and more airbuses, built by a consortium of European manufacturers, have been sold. In 1978 the US share of the world market sales dropped to 80 percent [6, p. 655]. The success of the airbus program does indicate that when the European producers get together--and specialize in a limited area--they can compete. But this has involved abandoning the longer range aircraft to the US. Overall, the figures indicate overwhelming US supremacy in the civil aviation

Table 4. US Designed Aircraft in World Civil Fleet at the End of 1976 (Percent of Dollar Value)

Fleet	Long Range	Other	Total
US	100.0	95.0	99.0
France/FRG/UK	85.0	53.0	71.4
Other Europe	99.8	87.1	94.2
Rest of World	99.7	75.7	89.0
World	97.5	87.3	91.9

Source: Reference [7, pp. 5-11].

market. The US dominates the civil aircraft market by an even greater degree than it dominates arms.

In summary, the "imbalance" on the "two-way street" of US-European arms trade is one in which the sales to smaller European countries are predominant. In recent years the French have bought less American military equipment. The situation is similar for the UK which had bought little from the US since the mid-1960s until their recent purchases of CH-47 helicopters and submarine-launched Harpoons. The FRG may cut back on imports from the US now that the compulsion of the offset agreement no longer exists. But because of their large inventory of US equipment, it will probably continue to buy and license US equipment for a number of years. Sales in the last five years--of $1.9 billion to the FRG and $1.2 billion to the UK indicate the cutback has not yet occurred for either country. The major penetration of US military equipment in the European market has been the F-16 aircraft and the AWACS aircraft and their impact will continue into the late 1980s.

Cooperation Among the Europeans. The chief formal engine for intra-European cooperation is the Independent European Program Group (IEPG), set up in late 1975 to accomodate France which refused to participate actively in Eurogroup, a NATO organization. The IEPG lists 24 cooperative programs in various stages of development and operational use [18, p. 97].

Looking first at aircraft programs, we see that of the seven fixed wing combat aircraft being produced or about to be produced in Europe and of the six being delivered to their forces (Table 5), three have been developed cooperatively. Dassault remains outside these agreements as far as its three high performance combat aircraft are concerned but is a participant in two others.

For purposes of comparison, the US, with three Services and many more than three missions, has developed five different types of fixed wing combat aircraft for its forces, is buying a sixth--the British developed Harrier and has designed and produced a seventh for export only. Even within one politically sovereign nation, the problems of gaining cooperation are not eliminated.

Table 5. Tactical Combat Fixed Wing Aircraft Produced or in Engineering Development in 1979

European

France

Dassault-Breguet F-1c
Dassault-Breguet 2000
Dassault-Breguet 4000 (export only) (9)

UK

British Aerospace Harrier (10)

France/FRG

Dassault-Breguet/Dornier Alpha-Jet

FRG/Italy/UK

Panavia (11)/Tornado

France/UK

Dassault-Breguet/British Aerospace Jaguar

US

Marine Corps McDonnell-Douglas AV-8 (10)
Air Force Fairchild A-10
Navy Grumman F-14
Air Force McDonnell-Douglas F-15
Air Force General Dynamics F-16
Navy McDonnell-Douglas/Northrop F-18
Export Northrop F-5 (export only)

Source: References [9-11].

Other weapons areas are being undertaken under arrangements of intra-European cooperation. France and the Federal Republic of Germany have developed three tactical missile systems cooperatively, while France has developed one other missile with UK and one with Italy. Whereas only 1 of 25 put into service before 1970 represents a cooperative effort, 6 of 14 since that date were developed by two or more countries (Table 6).

Table 6. Cooperative European Missile Development Programs, Major European Producers

Missile Type	Before 1970		1970 and After	
	Total	Cooperative	Total	Cooperative (12)
Surface-to-air	10	0	3	1
Air-to-air	5	0	3	0
Anti-tank	6	0	2	2
Air-to-surface	4	1	3	2
Surface-to-surface (anti-ship only)	0	0	2	1
TOTAL	25	1	14	6

Source: Reference [30].

Within Europe, cooperative development has taken two main forms. When France is involved, one or the other of the two partners takes the lead in a rather loose association. On the other hand, the United Kingdom and the Federal Republic of Germany have been willing to enter major agreements involving a third country and prefer a closer association with a separate management structure such as that--known as Panavia--created to develop the Tornado multi-role combat aircraft (13).

CONCLUSIONS

We have seen in this paper that the US dominates NATO arms R&D and production. Arms exports are an important part of arms production with France and the UK particularly dependent on sales to non-industrial countries.

The US has dominated the relatively small amount of arms trade among the four powers, selling a fair amount to the FRG and UK but buying almost no equipment from non-US sources. France sold only a small amount of military equipment while it bought essentially nothing from its European partners. The US has also dominated sales to other NATO countries with the recent purchase of the F-16 fighter standing out as a singularly important transaction.

The largest most complex and most expensive US weapons have been sold to Europeans under coproduction and licensing agreements, rather than sold as complete weapons. In a weapons related area, civil aircraft, the US finds itself dominating, not only the European but the world market in long distance aircraft with the European airbus making some in roads in the medium range aircraft.

Agreement among Europeans on standardized weapons is no easier than agreement across the Atlantic. Although there is some progress, Europeans find themselves developing many different types of aircraft and missiles with only limited--although increasing--cooperation.

US dominance of the market appears to follow naturally from the US size, two-thirds of the market, and US dominance in two categories of weapons; combat aircraft and air defense systems that are most important to the Alliance. US domination of the civil aircraft market suggests that the factors that influence the arms markets are not necessarily peculiar to arms, but extend to other high technology systems.

Additional cooperation can take place only if compromises are made that allow for increased participation by the Europeans in the development of these major arms categories and if all four countries are willing, with greater frequency, to adopt foreign designed weapons. Compromises would also have to be made on issues involving sales of weapons outside the Western Alliance.

The lack of such progress and compromise will mean, not that there will be no cooperation, but that we are reaching the limit of cooperation. Still increased development costs and a rising threat may drive the Alliance toward marginally more cooperation in the 1980s.

FOOTNOTES

(1) Other NATO countries, non-communist European countries outside NATO, plus Australia, Japan, and New Zealand.

(2) Official figures on arms trade as shown, for example, in [15] give an inaccurate picture of the arms trade flows. In particular, some coproduction work done in European countries and US procurement of components are not shown as US purchases although they should be for consistency if they are being used to measure trade flows across the Atlantic. With these omissions, the use of ratios of US-European arms trade, based on these figures, is totally meaningless.

(3) Medium NATO European producers and consumers: Belgium, Denmark, Italy, Netherlands, and Norway. These five countries buy their own arms are, therefore, of most concern as customers to the major producers. Greece and Turkey have not been included because the bulk of their imports continue to be supported by a combination of aid and special loan guarantees. Canada's arm imports and exports exceeded that of many European producer, but her arms trade was almost entirely with the US. For a discussion US-Canadian bilateral trade see Reference [1].

(4) These agreements were an important element in the relations between those countries and a point of friction particularly in the mid-1960s, possibly causing the fall of a Prime Minister [3, pp. 74-80]. Both [3] and [4] provide useful background on the offset program.

(5) The AWACS systems will cost about $1.9 billion of which half would be paid by the Europeans (30 percent FRG and 20 percent split among the others--not including France and the UK). The North American half would be 40 percent, US, and 10 percent, Canada [18, p. 932].

(6) The term <u>transfer</u> is used to cover equipment that is transferred from one country to another as a gift, through soft loans or sold for cash.

(7) As mentioned in footnote (2), the Official Defense Security Assistance Agency figures are gross sales that do not reflect offset arrangements. The coproduction arrangement called for General Dynamics to subcontract 58 percent of the European F-16 cost back to the countries procuring the aircraft. This reduces the total sale figure above by $2.2 billion as of late 1979 and eventually by $2.4 billion to satisfy the original agreement [19, p. 6]. Since no similar large sales have taken place between the five countries shown

above and the three major powers, the US dominates the NATO arms market among the smaller powers even if we reduce the $6.2 billion by $2.4 billion to $3.8 billion.

(8) The bulk of the major agreements between the US and the Europeans have been for fixed wing combat aircraft and air defense systems [12, pp. 19-23]. Not only do these weapons dominate past US-European transactions, but they are the most expensive of US and European general purpose force development programs. Thus, they should be of special concern in future cooperation. Paradoxically their military, economic, and political importance has itself been an impediment to cooperation.

(9) Although the French Air Force has not ordered this aircraft, it appears to be the French candidate for the NATO combat aircraft of the 1990s [16].

(10) Developed by UK as the Harrier with earlier US and FRG cooperation. Marine Corps is also developing its own more advanced variant for later delivery.

(11) Panavia consists of Messaschmitt-Bolkow-Blohm, Aeritalia, and British Aerospace.

(12) One US/UK system and one French/Italian system included in this column.

(13) For a discussion of preferences for these two types of organization see Reference [8, pp. 926-927].

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NATO RSI AND NATIONAL INDUSTRIAL STRUCTURES

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A key non-military rationale for promoting NATO RSI policy is the belief that a harmonization of the United States and European "defense industrial base" can serve to reduce the cost of developing, designing, and producing weapon systems.

This thesis assumes that the economic behavior and industrial dynamics of the market for military goods is a mirror image of that for civilian goods.

Our research suggests, however, that this mirror image does not exist. The economic savings projected by NATO RSI will not obtain until and unless some basic decisions are made about the size, scope, and content of the U.S. defense industrial base, i.e., unless and until the U.S. defense industrial base is appropriately rationalized to a predicted wartime demand.

The rhetoric of the language that describes the economics of the industrial side of the military acquisition process would suggest that those United States firms heavily involved in defense related production behave very much like their civilian counterparts. These descriptions inevitably portray the defense industries as highly competitive, constantly attaining, or at least reaching for, dollar saving economies of scale, and intimately concerned with fostering and promoting technological change and innovation. To the casual observer, and especially one socialized to think in terms of the "military-industrial complex", it would appear that defense contracts are highly desirable, high profit business eagerly sought after by major elements of American industry. One would also be led into believing that the defense industries are highly efficient or at least organized to maximize industrial effectiveness.

It is this rhetoric that has been used to promote the wisdom of the economic side of the NATO RSI policy. The underlying assumption behind the industrial particulars of the policy is the apparent belief that the properly executed integration of the existing U.S. and European industrial base will serve in the long run to reduce the overall cost of devloping, designing, and producing complex weapon systems. Various published articles have argued long and persuasively about the costs of duplicative research, the incremental cost of short production runs and, for Europe at least, the inherent inefficiencies of small, labor-intensive production lines. These articles argue equally persuasively that substantial sums of money could be saved by the Alliance if the ostensibly redundant military-oriented research and development now done by the U.S. and its production-oriented NATO allies were eliminated or at least reduced in scope. Further arguments suggest that the unit cost of weapons to be produced could also be reduced were output pooled to provide longer production runs. In general, shadow figures are presented to illustrate and document the contents of the vast savings available to the NATO alliance if the military acquisition process were harmonized internationally.

On first analysis, the figures present a compelling argument for harmonizing our industrial efforts. When the analysis is broadened to include the more critical need to enhance the military capability of the NATO Alliance. . . a need that is absolutely incontestable. . . the argument for industrial rationalization takes on an additional patina.

However, before accepting the argument for the cost savings that could be made available for enhancing the military posture of the Alliance, a number of critical industrial factors need to be analyzed:

First and foremost, how efficient are the defense industries now serving the various NATO nations? Are the various industrial groups and firms now participating in the military acquisition process being properly utilized by their respective nations, or are there critical internal redundancies that would have to be eliminated before any international effort in this regard would make either economic, industrial or financial sense? And what is the cost of eliminating these redundancies?

In this regard, it is reasonably evident that there are extensive redundancies in key elements of the U.S. defense industrial base whose elimination could do much to reduce the cost of our own military effort. However, we have made virtually no effort domestically to eliminate these redun-

dancies; that is to say, we have not moved in the United States towards a rationalization of our own defense industries in anticipation of a closer industrial collaboration with our European allies.

We have not done so for a great number of reasons; some good, some bad. The degree of "goodness and badness" is, of course, a matter of perspective. When economic rationalization is called for, that is the elimination of excess capacity or obsolete facilities, someone's ox has to be gored. If one benefits from the rationalization process, it is, of course, good. For the firm or person put out of work, industrial rationalization is, by definition, bad. To date, we have appeared to be unwilling to put people out of work, and have thus pursued a policy that avoided this type of outcome. However, the more critical reason for our failure to rationalize our own defense industry may be more transcendent than the job saving argument noted above. Our national ethos simply does not allow for the type of government intervention needed either to limit the number of firms competing for defense business, or otherwise force the retirement of outmoded, obsolescent or high cost facilities. In point of fact, we have no legal or institutional framework in the United States for accomplishing this. Because of this, we have not really faced up to the problem of the cost to our military effort of sustaining this redundant base. Instead, we have clung unremittingly to the notion of a free market and have substituted an economically unorthodox blend of intense price competition and work allocation procedures as one technique for remedying the problem. In so doing, we have failed to overtly recognize, as our European Allies have done, that there is no "logical place" in a market oriented, peacetime economy for a privately-owned, competition-oriented defense industrial base, and that specific governmental policies are absolutely essential if this excess capacity is to be eliminated. Simply put, in peacetime the market for military goods and services is not large enough to sustain the defense industrial base that was created in World War II and, at least in aircraft and shipbuilding, is still very much with us.

Because we have no institutional framework for eliminating this excess capacity, we are simply not prepared in the United States to rationalize our defense industries as are our European allies. Instead we seek to support the base as best we can, albeit at uneconomically low levels of output. Our NATO Allies do not, by the way, suffer from the same problem. They can and indeed have already forced the rationalization of much of their defense industry. Where necessary for economic and other reasons, they have also internationalized portions of their defense industry by creating transnational corporations. By so doing, they have in effect acted to limit the otherwise destructive effect of intense competition between nations for limited military markets. In geopolitical terms, they have moved rather rapidly and precisely to protect their national interests as they see them. In rather stark terms, they have subordinated the purely economic needs of their defense industries to, what are for them, other more pressing national needs. Our current call for the harmonization of their partially or fully rationalized defense industries with our own must, once the surface has been scratched, appear to them to be a rather strange request. We are suggesting to our Allies that they do internationally what we have failed to do domestically; that is, further rationalize an existing industrial base. Industrially, we are suggesting a contradiction in that we are proposing the marriage of a free market with that of a controlled or semi-controlled economy.

In assessing the economic and industrial wisdom of the purely economic aspects of the NATO RSI policy one then needs to explore the virtues and faults of an economically rationalized defense industry. Are there factors other than the political and institutional ones noted above that have prevented, or at least discouraged, an attempt to more rationally organize the U.S. defense industries? A deeper look at the question would suggest that there are indeed objective reasons for our overt failure to eliminate key redundancies in our own defense industrial base.

Two reasons appear to dominate here.

1. First and foremost, technological innovation is hard to predict or even anticipate. Given the overt American policy of seeking for revolutionary as opposed to evolutionary technological changes. . . eliminating any grouping of highly talented, research oriented engineers and support personnel would appear to be inappropriate if the effect of this elimination were to impede the potential for technological progress. Paradoxically, the time for eliminating and dispersing this talent bank might only occur during a prolonged conflict when technology was frozen in order to maximize the output of a relatively standardized product as in World War II. If, however, being on the cutting edge of technology is a paramount military need, then an otherwise redundant military industrial base may need to be maintained. This means that we should be willing to pay a premium for those technological innovations that enhance our war fighting capabilities. To the extent that we can maintain a sufficient qualitative edge to offset the qualitative superiority of our enemy, then the premium is surely cost effective.

   But if this conclusion is correct domestically as our current posture would suggest, why should not the same conclusion be drawn for our NATO Allies. To some extent, their proclaimed reliance on American technology would suggest that they have either failed to develop their own talent banks or that the industrial rationalization process that they have pursued may, indeed, be counterproductive in a highly charged technological environment. Thus, before any complete conclusions can be drawn on the economic aspects of the NATO RSI program, one needs to know more about the impact on technological growth of an otherwise legitimate attempt to eliminate high cost redundancies in R + D and production programs. Will such a

policy limit technological growth at a time and place when our military doctrine is heavily dependent on this growth? Is there any relevant experience here that we can draw on? In economic terms, are there forms of industrial structures that promote technological growth? If so, how do we identify and learn from them? The need for technological innovation may far outweigh the need for economic efficiency.

2. The more hidden fact of our defense industrial base is that we have excess capacity in a limited number only of industrial areas, chiefly at the level where we "assemble" major platforms, e.g., the aerospace and shipbuilding industry. We no longer have redundant capabilities. . . if ever we did. . . at the more basic industrial levels. On the contrary, we do not have adequate capacity in such basic industries as castings and forgings, machine tools, and the like. Similarly, we do not now appear to have sufficient capacity in the more sophisticated electronics and communications industries, i.e., those industries primarily responsible for producing high technology, mission related equipment. In these two areas, one might allege that we have allowed our defense industrial base to become overly rationalized. By relying too heavily on an unorthodox view of competition supplemented by an allocation process, we appear to have discouraged the continuing participation of a number of firms in the defense industrial process and have failed to provide incentives for the entry of others. If this is so, the more relevant question with respect to the industrial imperatives suggested by the NATO RSI policy is the further impact on our defense industrial strength of a legislated harmonization of U.S. with foreign industry? Will we further discourage the involvement of our industry in the defense procurement process? Will the fittest of those firms now involved. . . those most capable of competing in the civilian market. . . move further and further away from the defense acquisition process leaving only the less efficient economically and technologically to compete headlong with an otherwise rationalized European industrial structure? These are the questions then that need to be answered in assessing the economic side of our current NATO RSI policy.

The underlying question with respect to the industrial side of the NATO RSI policy then is the wisdom of applying conventional economic theory to the military acquisition process. As it is conventionally defined economic efficiency calls for forms of competition which minimize price, and by so doing maximize consumer choice. In this regard, the U.S. view of competition and efficiency is especially Darwinian. Meet the price or go out of business. One cannot argue too strenuously with the inherent wisdom of this approach with respect to consumer goods, where personal satisfaction is the economic criterion to be applied.

Applying the same theoretical base to the acquisition of military goods and services, however, may be wholly inappropriate if the effect is to discourage the entry by a large number of firms into the market for technologically oriented defense goods and services. Indeed, we would argue that redundancy in industrial capacity may well be absolutely essential if we are to continue to rely on a military doctrine that calls for technologically derived force multipliers as an offset to the quantitative superiority of our potential enemies. In a sense, I am suggesting that one cannot have it both ways; an economically rationalized, least cost defense industry and the type of technological innovation that breeds superior war fighting capability. The economics of a civilian market place cannot be applied without stringent reservations to the market for military goods and services.

In asserting the economic virtues of NATO RSI, then, it is essential to analyze rigorously the value of price-oriented industrial competition <u>as it has come to be defined by the Defense Acquisition Regulations and Congressional Policy</u>. If this special interpretation of conventional economic theory acts to discourage the continued participation in the defense market of high quality, technologically oriented firms, then such competition may be more of a negative force than we now anticipate. Broadening this view of competition to embrace the otherwise rationalized military industrial strength of our NATO Allies would, in turn, compound the problem by further limiting the opportunity for technological growth.

There is no question about the need to enhance the military strength of our NATO Alliance. Nor is there any question about the need to increase the purchasing power of our defense dollar. However, it is not a foregone conclusion that these two objectives can be gained by attempting to harmonize two disparate economic structures. Each of these structures has evolved in response to perceived national interests which, in and of themselves, are disparate. The international politics of the past ten to fifteen years would suggest the impossibility of this task.

If this is so, as we suspect it is, then the least-cost answer to the need for a war fighting capability may well require that we first define our national interests and second define the scope and content of the industrial structure needed to sustain these interests. But these actions should precede and not follow an attempt to rationalize our military industrial base with that of our European Allies. If we are not careful, we may well buy into an economic system that is the antithesis of the type of system that we wish to maintain.

THE DEPENDENCE OF EUROPEAN DEFENSE INDUSTRY ON ARMS EXPORTS AS A PROBLEM FOR INTERNATIONAL COOPERATION

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ABSTRACT

This study examines the apparent dependence of European defense industry on arms exports in sufficient detail to distinguish degrees of dependence in four principal sectors--aerospace, ship building, ground armaments, and electronics--for France, the UK, the FRC, Cermany, Italy, Belgian, and the Netherlands. Projections are made concerning the continuity and changes in patterns of exports that are likely during the 1980s. The impact of such projections on international cooperation in development, production and acquisition of major weapons is assessed; and conclusions are drawn for US policies on arms exports, international cooperation in R&D and production, and weapons acquisition for US-NATO forces.

INTRODUCTION

During the past three years, the US has sought simultaneously to achieve a basis for international agreement to limit the worldwide transfer of conventional arms through the so-called CAT (conventional arms transfer) talks and to improve transatlantic defense cooperation with NATO allies on weapons development, production, and procurement. The CAT talks, which are now in limbo, were a major aim of the "new conventional arms transfer policy" (PD 13), announced by President Carter on 19 May 1977 [1]. President Carter's speech to the NATO summit meeting in London a week earlier announced his Administration's firm commitment to NATO and invited a transatlantic dialogue "to explore ways to improve [allied] cooperation in the development, production, and procurement of defense equipments" [2]. The ensuing push for NATO RSI (rationalization/standardization/interoperability) needs no elaboration here. Both pursuits--one relatively inactive, but of continuing concern; the other active, and of limited success--have confronted a common obstacle in the extent to which NATO allies and their defense industries have apparently become dependent on arms exports.

Arms exports of sovereign states serve several national policies and interests, and it would be simplistic to attempt to reduce them to only one or two causes. As presented in Table 1, data compiled by ACDA indicate that the US, France, and the UK have been the principal net exporters of arms among the NATO allies during the 1970s. All three have had foreign policy reasons for supplying particular friends and allies with modern military equipment, including high-technology weapon systems. Key among those reasons have been (a) to respond to perceived security requirements of friends and allies in potentially volatile regions of the Third World: and (b) to maintain influence in regions where access to raw materials and energy have been vital to the economies of the West.

Besides such elemental foreign policy reasons--the prudence and success of which have been debatable--other economic reasons have been important also. One national reason has been closely related to (b) above after the oil embargo of 1973-74 and the ensuing increase in the price of crude oil by the OPEC states. That has been for arms exports to be an earner of foreign exchange in one critical trade relationship as well as being necessary for establishing general trading relationships. While arms exports have historically been less than 2% of all exports for France and the UK and less than 1% for all other NATO allies except the US according to statistics such as shown in Table 2, that small percentage is regarded as vital and likely to be increasingly vital to NATO European states. In comparison, for the US during the period 1967-76, arms exports amounted to more than 6% of all exports with about half of those exports going to oil-producing states.

INDUSTRIAL CONSIDERATIONS

Beyond such national foreign policy and economic reasons for exporting arms--particularly to less developed countries (LDCs)--there have been economic-industrial reasons for arms exports that make them far more important to European NATO states than to the US. Briefly stated, this difference derives directly from the relative sizes of US and European economies and national defense markets. No European NATO state has had an overall military budget higher than about one-seventh the size of the US budget during the 1967-1976 period (see Table 2). Weapons and equipment budgets have been even smaller in comparison. The relatively low-volume procurement of high-technology systems such as combat aircraft for national forces drives the unit cost of such systems extremely high without the relief of arms exports to provide larger and longer production runs. If restricted only to their own national defense markets, European defense industries, in the high-technology, low-volume area in particular, are denied the opportunity to spread R&D and investment costs over a large production and to benefit from learning curve economies associated with the longer production runs that US defense industry typically enjoys.

Table 1. Net Exports of Arms of Principal NATO States by Year 1967-1976 (Value in Millions of 1975 %)

Year	US	CAN	FRG	UK	FR	ITALY	NETH	BEL
1967	3349	56	-207	-120	101	- 20	- 28	- 32
1968	3808	99	17	-320	252	- 58	- 25	- 34
1969	4749	250	-158	-227	290	- 88	- 54	- 33
1970	4032	177	- 30	40	258	- 34	-127	-105
1971	4231	212	-288	143	190	- 33	- 98	- 25
1972	4971	222	-250	545	892	-131	- 3	6
1973	5776	109	-585	647	1012	- 3	68	10
1974	4384	- 6	-382	502	726	36	- 9	42
1975	4706	-106	-132	385	623	124	23	- 16
1976	4867	- 70	184	426	759	128	- 17	37

Source: United States Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers 1967-1976, Washington, D. C., 1978. Table VI, pp 120-156 [3].

Table 2. Comparative Statistics of Principal NATO States (Annual Averages, 1967-1976)

State	Population (Millions)	GNP (Billions of 1975 $)	Mil Ex (Billions of 1975 $)	Arms Exp (Millions of 1975 $)	Arms Imp (Millions of 1975 $)	Arms BOT (Millions of 1975 $)	Ratio of Arms Exp/ Imp	Arm[illegible] as % of All Exp
United States	207.7	1450.5	102.77	4686.0	198.7	4487.3	23.58	6.28
Canada	21.7	134.0	3.04	178.3	84.0	94.3	2.12	0.65
FRG	61.1	397.8	14.07	263.2	446.3	-183.1	0.59	0.41
UK	55.7	216.6	11.04	401.4	199.3	202.1	2.01	1.23
France	51.5	300.0	12.32	534.9	24.6	510.3	21.74	1.54
Italy	54.3	157.2	4.54	121.6	129.5	- 7.9	0.94	0.51
Netherlands	13.2	74.9	2.58	44.1	71.1	- 27.0	0.62	0.19
Belgium	9.7	55.9	1.62	47.9	62.9	- 15.0	0.76	0.23

Source: US Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers, 1967-1976, Washington, D. C., 1978, Table II, pp. 33-71; Table IV, pp. 76-114, Table VI, pp 120-156 [3].

Notes: Mil Ex = Military Expenditures
Arms Exp = Arms Exports (value of deliveries)
Arms Imp = Arms Imports (value of deliveries)
Arms BOT = Arms Balance of Trade (Exp - Imp)

Most of the smaller European NATO states have accepted the brutal economics of their small markets and have largely foregone sustaining an independent high-technology defense industry. Such a course has been largely unacceptable, however, to the major European NATO allies (i.e., France, the UK, the FRG, and, to a lesser extent, Italy). At least three major reasons can be adduced for wanting to maintain a relatively independent (or, better, non-dependent) high-technology defense industrial base. These are:

- To maintain relative political autonomy within NATO. (This is especially important for France, but not confined to France.)

- To sustain a vital and viable non-military industrial base that is widely believed to be partially dependent on spinoff benefits from military R&D.

- To sustain a technological base that can provide relatively independent technological judgment for decisions to purchase from outside one's own economy. (This has been especially important to the FRG, but not confined to it.)

To maintain a high-technology defense industrial capability for such reasons in the face of low-volume national procurement, the major NATO European allies have been limited to about four options, none of which has been entirely satisfactory but all of which have been accepted to some degree. These are:

- To accept diseconomies of small-scale, low-volume production as the price of sovereignty as a middle power (e.g., French strategic missile industry).

- To collaborate with similar states to share the high cost of R&D and to achieve some economies of volume production. This is one of the major patterns followed by France, the UK, the FRG, and Italy in the long list of successful intra-European collaborations that have emerged in the last 10 to 15 years.

- To accept and even actively seek outside markets and, especially, extra-NATO markets for weapon systems developed and produced by domestic industry.

- To seek to penetrate the large US market and redress the imbalance on the "two-way street."

With respect to the last point--which is the principal European slogan for transatlantic weapons cooperation--all European NATO states accept to some degree that they will continue to purchase or otherwise acquire (co-produce) US-designed weapon systems in some high-technology areas. However, they would argue that it is in the long-term US interest as well as their own that "dependence" on US defense industry not be continued at the expense of endangering a technologically, if not politically and economically, independent European defense industry.

THE CASE OF THE SMALLER NATO STATES

The smaller European NATO states--with even smaller national markets than France, the UK, and the FRG and with less diversified and sophisticated technological capabilities or potentials--accept their dependence on arms imports to supply their forces with major weapon systems. Nonetheless, for economic and security reasons, most of them increasingly feel that they cannot indefinitely sustain a large negative balance of trade in their military accounts. While the balance of trade in their military accounts may not appear to be significant in comparison to their overall balance of trade, most feel that they cannot politically sustain net negative balances in the military trade account and support their necessary military budgets. This is especially true, for example, for Belgium and Italy, and, to a lesser extent, for the Netherlands [4]. A negative balance in the military trade account is perceived by their publics to mean that they are paying double for their relatively small forces: first, by direct taxation and its opportunity costs, and, second, by "exporting" jobs and industry.

Only two main avenues of recourse appear to be open for acquiring the high-cost weapon systems their military forces require. These are:

- To demand a share in the production of the systems they buy from outside by licensed production arrangements and other forms of compensation or offset.

- To foster exports of those systems for which an indigenous capability for development and production does exist.

With respect to the second point, Fabrique Nationale in Belgium, for example, is a major worldwide exporter of small arms. Thus, while arms exports from several smaller European states do not appear to be large in the overall arms transfer problem, especially when measured in monetary value and even in their net balance of military trade, they are regarded as vital to their own economies and to their more limited foreign policy roles.

EMPLOYMENT STABILITY

One point that is common to both major and smaller European NATO states and their defense industries is the extent to which they apparently have come to depend on arms exports for stability and continuity in their defense production base. This "characteristic" of European defense industry makes the role of arms exports politically as well as economically sensitive. This is an important point, but one that is frequently overstated or misunderstood. The estimates shown in Table 3, indicate that, in terms of overall workforce, defense industries in France and the UK account for only about 2.5-3.5% of total industrial output and about 4-5% of manufacturing output. This compares to 7-8% of total industrial output and 10-11% of manufacturing output for the US in the 1967-1976 period [5]. For most European states, national requirements and replacement schedules alone do not provide steady markets for even this relatively

Table 3. Relative Economic Importance of Defense Industry Output (Annual Averages, 1967-1976)

State	Low Estimate[a]		High Estimate[b]	
	% of Total Ind. Output[c]	% of Man. Ind. Output[d]	% of Total Ind. Output	% of Man. Ind. Output
United States	6.8	7.9	9.7	11.2
Canada	0.9	1.2	1.4	1.8
FRG	1.0	1.1	1.7	1.9
UK	2.5	2.8	4.1	4.6
France	3.0	3.4	4.4	5.0
Italy	0.8	0.9	1.3	1.4
Netherlands	1.3	1.5	1.7	2.0
Belgium	0.7	0.8	0.9	1.0

[a]Includes major equipment only. Derived from NATO figures [6].

[b]Includes major equipment, ammunition, and military R&D. Derived from Rand figures [7].

[c]Uses OECD figures to estimate industrial output as % of GNP [8].

[d]Uses OECD figures to estimate manufacturing output as % of GNP [8].

smaller (in comparison to the US) industrial capacity devoted to defense. In view of this difference and the foregoing discussion of the importance of European defense industry to European states' concepts of their sovereignty, national security, and economic interests, it is understandable that Europeans should be especially concerned about maintaining the stability of the workforce in their defense industries. Arms exports provide a convenient, if not necessary, gapfiller for productive capacity when production runs for national procurement are completed.

In addition, European states by social custom and legislation have developed labor and employment practices to ensure job security and employment stability far beyond what obtains in the US. Custom and legislation do not allow, in Europe, the large reductions in force in defense industries that usually occur in US defense industry when particular national procurements are reduced or cancelled. This emphasis on workforce and employment stability in Europe gives a momentum or inertia to their defense industry production rates that tends to drive the arms export market as much as the demand side of that market.

THE PROBLEM

US policies on arms transfer restraints and on weapon systems standardization and interoperability are perceived by Europeans to affect vitally their own defense industry and its role in their foreign policy, national security, and industrial/economic viability. Europeans are especially sensitive to how US policies would restrict the role played by arms exports in European defense industry--a role that is smaller in national macroeconomic terms in comparison to the US, but in many other ways far more important to European defense industry as a whole and to the viability of high-technology defense industries in particular. That role is already changing as some of the traditional LDCs that have been the principal recipients of European as well as US arms exports are building their own indigenous defense industry capabilities and demanding co-production and licensed production in lieu of direct purchase.

The future of US policies and negotiations on CAT and on weapons cooperation in NATO is significantly clouded by the role arms exports have played and are likely to play in the further development of European defense industry. The broad characteristics of this problem are widely recognized in general, but controversial in detail and--so far, at least--apparently largely intractable of solution. Highly competitive economic and industrial interests of sovereign nations are at stake, whatever degree of alliance solidarity at the political and security level is intended or presumed. The French, for example, can reasonably be expected to design and produce fighter aircraft and tactical missiles independently of other allies as they are able and when a non-French and non-NATO market seems necessary for economic and industrial, if not political, reasons. Similarly, the British may be expected--without subverting the alliance--to design, produce, and market main battle tanks or combat ships independently of other allies for similar reasons.

What probably is not possible in the face of competing and highly stratified and different structures of economic and industrial interests among the NATO allies is some "grand solution" that could

be applied equally to all weapon system types and to all partners, independently of their particular defense-industrial structures. On the other hand, strictly "ad hoc solutions" may not be solutions at all, but merely acceptance of debilitating divergence in economic and industrial interests. Better to harmonize competing (and sometimes conflicting) national interests in the design, manufacture, and sale of weapon systems and better to reconcile US policies on arms export restraints and weapons cooperation in NATO evidently lies someplace between "grand" and "ad hoc" solutions.

REQUIRED DATA AND ANALYSIS

To assist US policy makers in evaluating the realistic alternatives that are open to both the US and European NATO allies and their defense industries in ameliorating or accommodating the role played by arms exports, a GRC study team is in the process of developing a highly structured and detailed data base on European defense industry and their arms exports. This work is sponsored jointly by OASD/ISA/IEA and USACDA. The Vertex Corporation of Rockville, Maryland, and Hoagland, MacLachlan & Co., of Wellesley, Massachusetts, are assisting the GRC study team in data collection and analysis.

The data base covers all major weapons systems developed and produced by defense industry in France, the UK, the FRG, Italy, Belgium, and the Netherlands during the decade of the 1970s and projected for the decade of the 1980s. The data base is divided into eight major parts, seven of which will be completed in first draft at the end of May 1980--too late for summarization in the advance Proceedings of the Ninth Annual DoD/FAI Acquisition Research Symposium. Oral presentation at the Symposium will summarize and highlight five of the seven completed parts of the data base.

The eight major parts of the data base are the following:

A. Exports and Production of European Fighter Aircraft, 1970-1989.

B. Exports and Production of European Military Helicopters, 1970-1989.

C. Exports and Production of European Tactical Missiles, 1970-1989,

D. Exports and Production of European Combat Ships, 1970-1989.

E. Exports and Production of European Armored Vehicles and Self-Propelled Artillery, 1979-1989.

F. Exports and Production of Major European Electronic Warfare Systems, 1979-1989.

G. Principal Manufacturers of European Weapon Systems.

H. Manufacturing Relationships for Production of Major European Weapon Systems.

Parts A-F are organized by country. For each weapon system category, all systems and their major variants produced or expected to be produced are identified and tables are presented showing numbers of units produced and exported by year, distribution of exports by region, and the value of exports and production for the decade of the 1970s and projected for the decade of the 1980s.

Part G is similarly organized by country. It attempts to list and briefly describes by characteristics such as ownership, principal subsidiaries, primary products, secondary products, collaborative relationships, and selected statistics of all manufacturers of weapon systems and principal components above a cut-off size (generally about 1000 employees in the larger states, and about 300 employees in the smaller states).

Part H is organized by the weapon system categories of Parts A-F. For each system identified in those Parts, it lists the prime contractor and the principal component manufacturer.

The oral presentation at the Symposium will deal with Parts A-E and present some tentative conclusions. Questions will be entertained concerning all parts of the data base and their development and structure.

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SESSION 14

FINANCIAL MANAGEMENT AND BUDGETING

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AUTOMATION OF PROGRAM/PROJECT COST REPORTS WITHIN DOD

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ABSTRACT

The Office of the Secretary of Defense (OSD) has a responsibility to monitor the progress of major defense acquisition programs. To assist in this effort, the Acquisition Management Information Division of the Office of the Assistant Secretary of Defense (Comptroller) has developed a quarterly reporting procedure and analysis capability to track cost performance on major contracts. The report is based on data provided to the Program Office in the Cost Performance Report. This paper addresses the development and use of contract performance data in OSD.

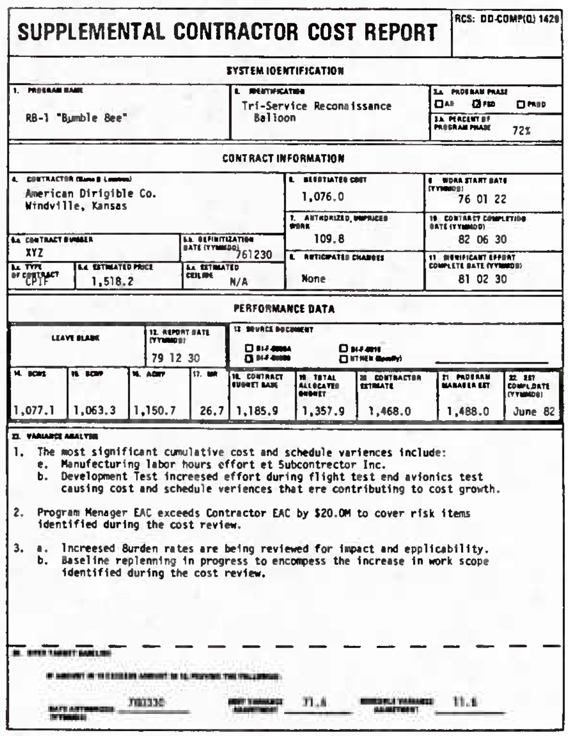
SUPPLEMENTAL CONTRACTOR COST REPORT

The Program Manager is not the only person in DoD interested in program performance. Many levels of management, up to and including the Office of the Secretary of Defense (OSD), are vitally concerned with the status and current performance trends of major acquisition programs.

Higher levels of management generally have access to various formal and informal sources of program information including regular contact with key program office and contractor personnel. However, while awareness of specific problems is essential, being able to quantify their impact on a program is often quite difficult. It is important for management to be able to step back periodically and look at the overall picture in order to evaluate trends and determine the potential impact of problems on a total program basis. To accomplish this, it is necessary and appropriate for all levels to have sufficient information to provide adequate visibility. Management's challenge is to obtain such information without imposing unnecessary and burdensome reporting requirements on the Program Office. The Cost Performance Report (CPR) is ideally suited to this requirement.

The CPR was designed primarily as a tool for the Program Manager. It is intended to give him an uncluttered summary of the status of his major contracts. While the CPR occasionally identifies contract problems for the first time, its main purpose is to confirm and quantify the impact of problems, both known and unknown, on the contract. It is the only standard DoD report which does this on a systematic basis. As such, it can be an extremely valuable management tool.

Summaries of CPR data are being used successfully to provide OSD and intermediate levels within DoD with the visibility desired for monitoring selected ongoing programs. The data is provided via the Supplemental Contractor Cost Report (SCCR) which is prepared quarterly by the Program Office from the latest CPR. With few exceptions, all SCCR data is taken directly from the CPR without the need for further calculations. Therefore, the reporting burden on the Program Office is minimized. The Supplemental Contractor Cost Report is forwarded through Service channels to the Office


SUPPLEMENTAL CONTRACTOR COST REPORT
RCS: DD-COMP(Q) 1429

SYSTEM IDENTIFICATION

RB-1 "Bumble Bee"
Tri-Service Reconnaissance Balloon
72%

CONTRACT INFORMATION

American Dirigible Co.
Windville, Kansas
1,076.0
76 01 22
109.8
82 06 30
XYZ
761230
None
CPIF
1,518.2
N/A
81 02 30

PERFORMANCE DATA

LEAVE BLANK
79 12 30

1,077.1	1,063.3	1,150.7	26.7	1,185.9	1,357.9	1,468.0	1,488.0	June 82

1. The most significant cumulative cost and schedule variences include:
   e. Manufecturing labor hours effort et Subcontrector Inc.
   b. Development Test increesed effort during flight test end avionics test causing cost and schedule veriences that ere contributing to cost growth.
2. Program Menager EAC exceeds Contractor EAC by $20.0M to cover risk items identified during the cost review.
3. a. Increesed Burden rates are being reviewed for impact and epplicability.
   b. Baseline replenning in progress to encompess the increase in work scope identified during the cost review.

FIGURE 1. SUPPLEMENTAL CONTRACTOR COST REPORT

of the Assistant Secretary of Defense (Comptroller) (OASD(C)) for processing and analysis. Figure 1 depicts the report format.

Once received, the information is stored in a computerized database. Although only limited data is stored, the database has facilitated the design of an analysis system involving numerous automated routines, computer graphics, and cost-at-completion projections. The automated system is called Contractor Performance Measurement Analysis (CPMA).

MAJOR SYSTEMS COST STATUS REPORT

As a result of the review of CPMA outputs, analysts from the Acquisition Management Information Division (AMID) of the OASD(C) identify contracts with variances or unfavorable trends which appear to be impacting the program significantly. Those contracts which warrant management attention are identified in the Major Systems Cost Status Report to the Under Secretary of Defense Research and Engineering (USDR&E) in his role as the Defense Acquisition Executive. The report highlights most contracts which are currently deviating from plan by 10 percent or more or which are projected to deviate by 10 percent or more by the contractor, the Program Manager, or by AMID. For each of those contracts, a recapitulation of the data, a brief narrative analysis, and two performance charts are provided. AMID's role is to flag programs which are experiencing poor performance, not to delve into program problems in depth. That role is the responsibility of the USDR&E action officer responsible for the program. The remainder of this paper describes in detail the CPMA outputs and the contents of the Major Systems Cost Status Report. For the sake of realism, the discussion examples have been derived from actual data.

CPMA OUTPUT

All CPMA input is derived from the quarterly SCCR shown in figure 1. The first 11 items will generally change only when the contract is changed. The remaining items are extracted from the bottom line of the CPR. Assuming that the Program Manager maintains a current estimate of contract cost at completion, the only information generated specifically for the SCCR is the variance analysis. This short narrative should be a summary of the CPR variance analysis provided by the contractor.

After loading the current SCCR data, the AMID analyst is provided a contract summary, tabular summaries of all current and previously reported data, and graphical displays of contract performance and variance trends.

The contract summary (figure 2) is a working copy of the summary to be included in the Major Systems Cost Status Report. The working copy differs from the final primarily in that it includes five "projected cost at completion" entries. For the purpose of

CONTRACT PERFORMANCE SUMMARY

SYSTEM: RB-1 REPORT PERIOO: NOV79

DESCRIPTION: AIR BAG DEVELOPMENT
CONTRACT NO./TYPE: XYZ; CPIF/AF START: JAN76
CONTRACTOR: AMERICAN DIRIGIBLE ORIGINAL COMPLETION: APRB2
REPRESENTS: 72% OF FULL SCALE DEVELOPMENT CURRENT COMPLETION: JJNB2
OVER TARGET ADJUSTMENT: $172.0

	DOLLARS	PERCENT
A. BUDGETEO COST FOR WORK SCHEOULED(BCWS):	$940.7	79%
B. BUDGETEO COST FOR WORK PERFORMEO(BCWP):	$92B.6	7B%
C. ACTUAL COST OF WORK PERFORMED(ACWP):	$1,150.7	97%
O. SCHEOULE VARIANCE (B)-(A):	$-12.1	-1%
E. COST VARIANCE (B)-(C):	$-222.1	-24%
F. TARGET COST:	$1,1B5.9	100%
G. CONTRACTOR'S ESTIMATE AT COMPLETION:	$1,46B.0	124%
H. VARIANCE AT COMPLETION (F)-(G):	$-2B2.1	-24%
I. PROGRAM MANAGER'S ESTIMATE AT COMPLETION:	$1,4BB.0	125%
PROJECTED COST AT COMPLETION METHOD 1:	$1,469.5	124%
PROJECTED COST AT COMPLETION METHOO 2:	$1,535.2	129%
PROJECTED COST AT COMPLETION METHOO 3:	$1,473.7	124%
PROJECTEO COST AT COMPLETION METHOO 4:	$1,472.B	124%
PROJECTED COST AT COMPLETION METHOO 5:	$1,472.5	124%
OASD(C)/MS ESTIMATE AT COMPLETION:	______	___

REMARKS:

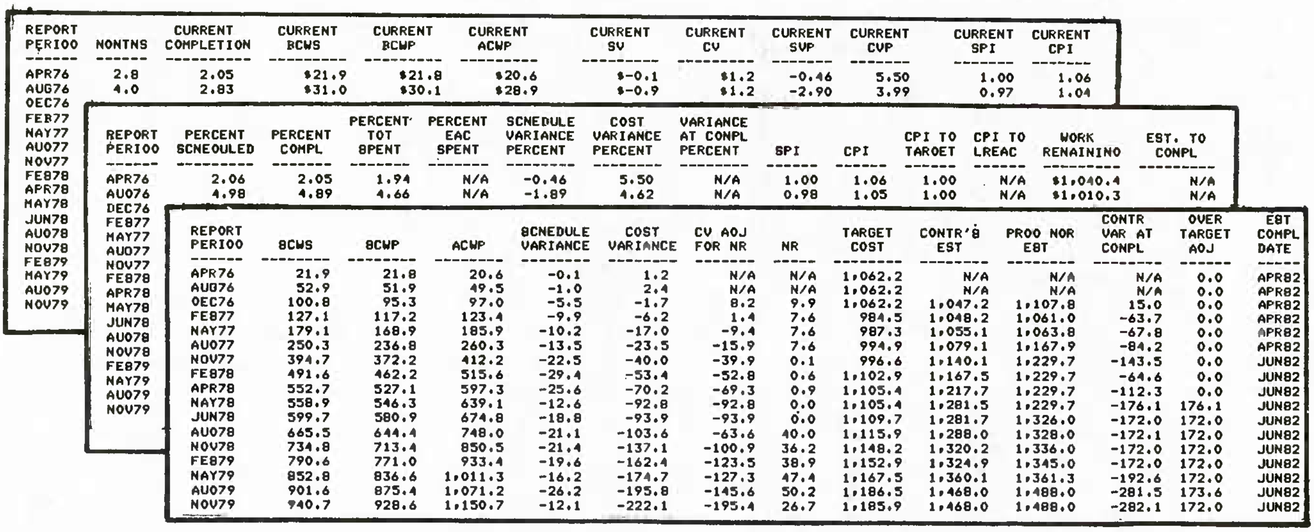
FIGURE 2. CONTRACT WORKING SUMMARY

this paper, it is only necessary to know that the projections are based on variations of standard performance index techniques. The purpose is to provide the analyst with a feel for the reasonableness of the contractor and Program Manager Estimate at Completion (EAC). The standard projections may or may not be the basis for the AMID EAC.

The tabular summaries (figure 3) provide the analyst with cumulative data in absolute and percentage terms, current period data, cost and schedule performance indices, work remaining, and the theoretical cost performance index required to complete the remaining effort on target or within the contractor's EAC. The summaries also display management reserve and budget in excess of the Contract Budget Base (i.e. over target baseline data).

The contract performance chart (figure 4) displays the cumulative trends for: Budgeted Cost of Work Scheduled (BCWS); Budgeted Cost of Work Performed (BCWP); and Actual Cost of Work Performed (ACWP). A unique feature of the CPMA performance chart is that it also displays changes in target cost and changes in the contractor and Program Manager EACs.

Following contract target cost is essential to the task of predicting ultimate contract cost. Projections of EAC based on the current target are likely to be understated if there is potential for large increases in target cost. The final piece of information provided by this chart is a track of changes in the scheduled completion date. Any imbalance between



REPORT PERIOD	MONTHS	CURRENT COMPLETION	CURRENT BCWS	CURRENT BCWP	CURRENT ACWP	CURRENT SV	CURRENT CV	CURRENT SVP	CURRENT CVP	CURRENT SPI	CURRENT CPI
APR76	2.8	2.05	$21.9	$21.8	$20.6	$-0.1	$1.2	-0.46	5.50	1.00	1.06
AUG76	4.0	2.83	$31.0	$30.1	$28.9	$-0.9	$1.2	-2.90	3.99	0.97	1.04
DEC76											
FEB77											
MAY77											
AUG77											
NOV77											
FEB78											
APR78											
MAY78											
JUN78											
AUG78											
NOV78											
FEB79											
MAY79											
AUG79											
NOV79											

REPORT PERIOD	PERCENT SCHEDULED	PERCENT COMPL	PERCENT TOT SPENT	PERCENT EAC SPENT	SCHEDULE VARIANCE PERCENT	COST VARIANCE PERCENT	VARIANCE AT COMPL PERCENT	SPI	CPI	CPI TO TARGET	CPI TO LREAC	WORK REMAINING	EST. TO COMPL
APR76	2.06	2.05	1.94	N/A	-0.46	5.50	N/A	1.00	1.06	1.00	N/A	$1,040.4	N/A
AUG76	4.98	4.89	4.66	N/A	-1.89	4.62	N/A	0.98	1.05	1.00	N/A	$1,010.3	N/A
DEC76													
FEB77													
MAY77													
AUG77													
NOV77													
FEB78													
APR78													
MAY78													
JUN78													
AUG78													
NOV78													
FEB79													
MAY79													
AUG79													
NOV79													

REPORT PERIOD	BCWS	BCWP	ACWP	SCHEDULE VARIANCE	COST VARIANCE	CV ADJ FOR NR	NR	TARGET COST	CONTR'S EST	PROG MGR EST	CONTR VAR AT COMPL	OVER TARGET ADJ	EST COMPL DATE
APR76	21.9	21.8	20.6	-0.1	1.2	N/A	N/A	1,062.2	N/A	N/A	N/A	0.0	APR82
AUG76	52.9	51.9	49.5	-1.0	2.4	N/A	N/A	1,062.2	N/A	N/A	N/A	0.0	APR82
DEC76	100.8	95.3	97.0	-5.5	-1.7	8.2	9.9	1,062.2	1,047.2	1,107.8	15.0	0.0	APR82
FEB77	127.1	117.2	123.4	-9.9	-6.2	1.4	7.6	984.5	1,048.2	1,061.0	-63.7	0.0	APR82
MAY77	179.1	168.9	185.9	-10.2	-17.0	-9.4	7.6	987.3	1,055.1	1,063.8	-67.8	0.0	APR82
AUG77	250.3	236.8	260.3	-13.5	-23.5	-15.9	7.6	994.9	1,079.1	1,167.9	-84.2	0.0	APR82
NOV77	394.7	372.2	412.2	-22.5	-40.0	-39.9	0.1	996.6	1,140.1	1,229.7	-143.5	0.0	JUN82
FEB78	491.6	462.2	515.6	-29.4	-53.4	-52.8	0.6	1,102.9	1,167.5	1,229.7	-64.6	0.0	JUN82
APR78	552.7	527.1	597.3	-25.6	-70.2	-69.3	0.9	1,105.4	1,217.7	1,229.7	-112.3	0.0	JUN82
MAY78	558.9	546.3	639.1	-12.6	-92.8	-92.8	0.0	1,105.4	1,281.5	1,229.7	-176.1	176.1	JUN82
JUN78	599.7	580.9	674.8	-18.8	-93.9	-93.9	0.0	1,109.7	1,281.7	1,326.0	-172.0	172.0	JUN82
AUG78	665.5	644.4	748.0	-21.1	-103.6	-63.6	40.0	1,115.9	1,288.0	1,328.0	-172.1	172.0	JUN82
NOV78	734.8	713.4	850.5	-21.4	-137.1	-100.9	36.2	1,148.2	1,320.2	1,336.0	-172.0	172.0	JUN82
FEB79	790.6	771.0	933.4	-19.6	-162.4	-123.5	38.9	1,152.9	1,324.9	1,345.0	-172.0	172.0	JUN82
MAY79	852.8	836.6	1,011.3	-16.2	-174.7	-127.3	47.4	1,167.5	1,360.1	1,361.3	-192.6	172.0	JUN82
AUG79	901.6	875.4	1,071.2	-26.2	-195.8	-145.6	50.2	1,186.5	1,468.0	1,488.0	-281.5	173.6	JUN82
NOV79	940.7	928.6	1,150.7	-12.1	-222.1	-195.4	26.7	1,185.9	1,468.0	1,488.0	-282.1	172.0	JUN82

FIGURE 3. TABULAR DATA SUMMARIES

performance trend lines and completion date can signify potential cost problems. In addition, significant changes in target cost without a related schedule change will often be a precursor of future cost problems.

The variance trend chart (figure 5) displays cost and schedule trends as well as changes in management reserve. Tracking management reserve is critical since it is usually applied to near term effort thereby tending to dampen the cost variance line. It is often a signal of current problems with a potential for future adverse cost impact. This is particularly true if it is being used at a rapid pace with significant effort remaining on the contract. Figures 6 and 7 demonstrate the value of following management reserve even on a program which is very successful in terms of cost and schedule. Figure 6 shows an actual Engineering Develop-

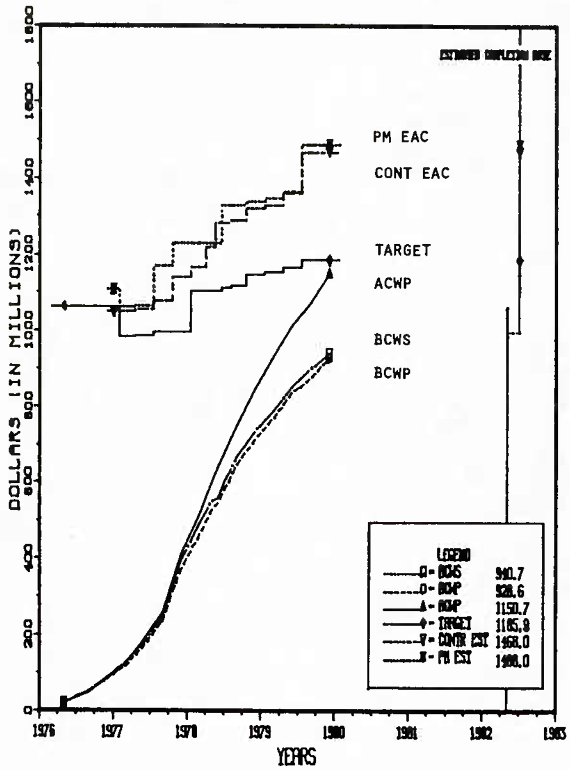


FIGURE 4. CONTRACT PERFORMANCE

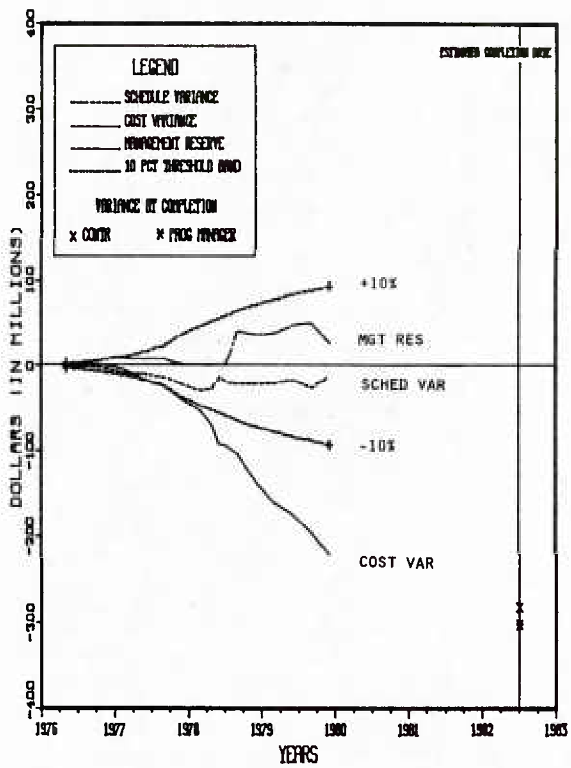


FIGURE 5. COST/SCHEDULE VARIANCE TRENDS

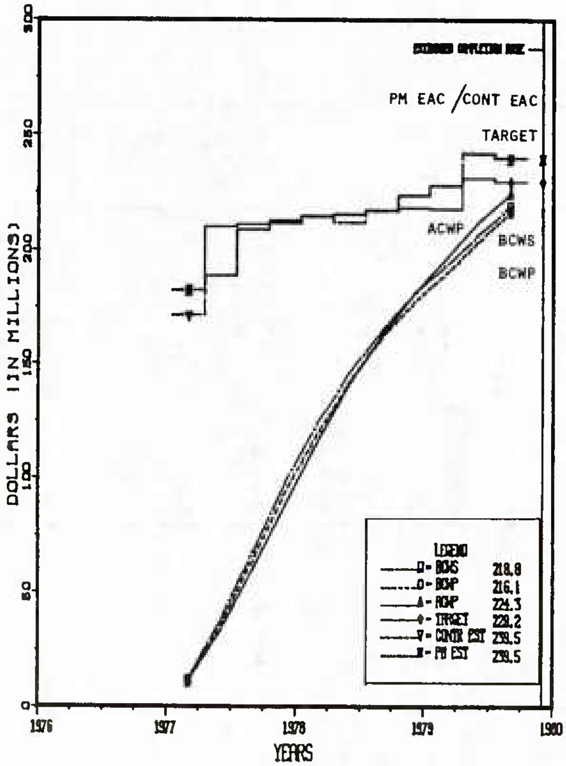


FIGURE 6. CONTRACT PERFORMANCE

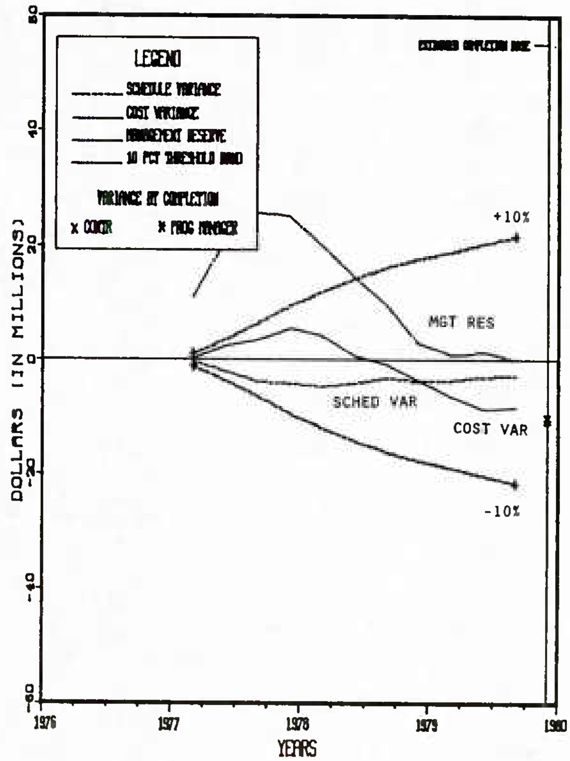


FIGURE 7. MANAGEMENT RESERVE/VARIANCE TRENDS

ment contract (obviously not the one we have been discussing). With the contract 94 percent complete, the chart shows a very successful program wit, a projected overrun of less than 5 percent. However, figure 7 shows that management reserve, which at one time was nearly 12 percent of contract value, was almost completely used up in the 15-month middle period of this 33-month effort. As stated earlier, use of management reserve is usually indicative of program problems. In fact, this program experienced severe technical problems. Fortunately, management reserve was available to solve these problems, but this is not the most interesting aspect of this program. Notice that the reserve was more than tripled in value in the early stages of the contract and at a time when costs were underrunning budgets. This was accomplished through the program manager's efforts to get the contractor to squeeze as much budget as possible from downstream work to provide "motivational" budgets and to insure availability of budget if problems were encountered. Because of the natural tendancy to "spend" the budget available for a task, it is almost certain that early cooperation between this Project Office and the contractor saved the government millions of dollars. Before leaving this subject, it is interesting to note what the "true" cost performance trend on this program was. Figure 8 displays the "cost variance" as the sum of the cost variance and management reserve usage.

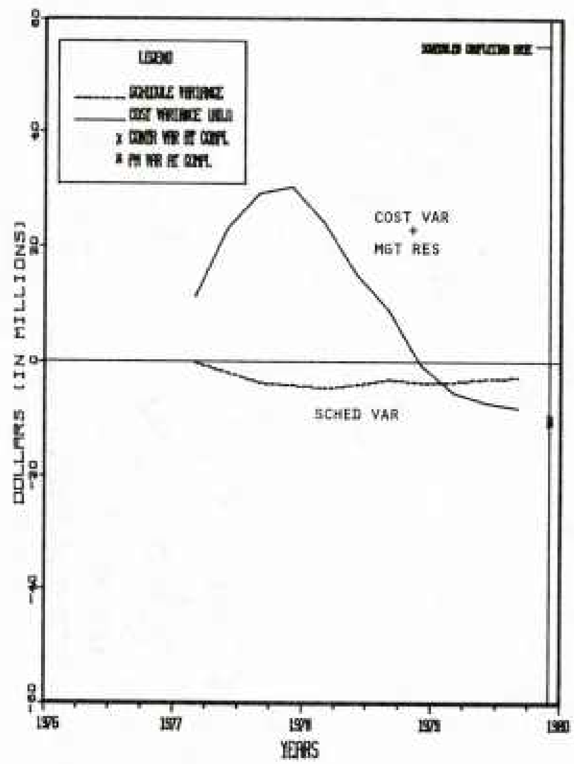


FIGURE 8. MANAGEMENT RESERVE PLUS COST VARIANCE

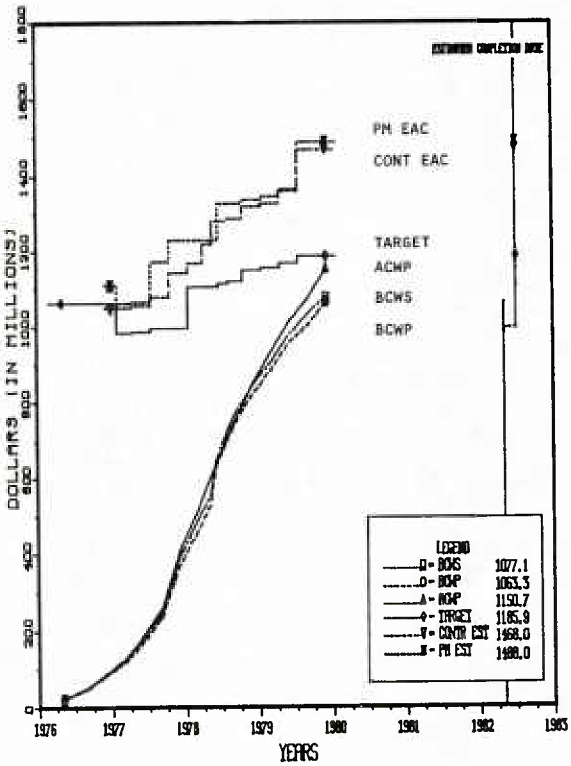


FIGURE 9. UNADJUSTED PERFORMANCE

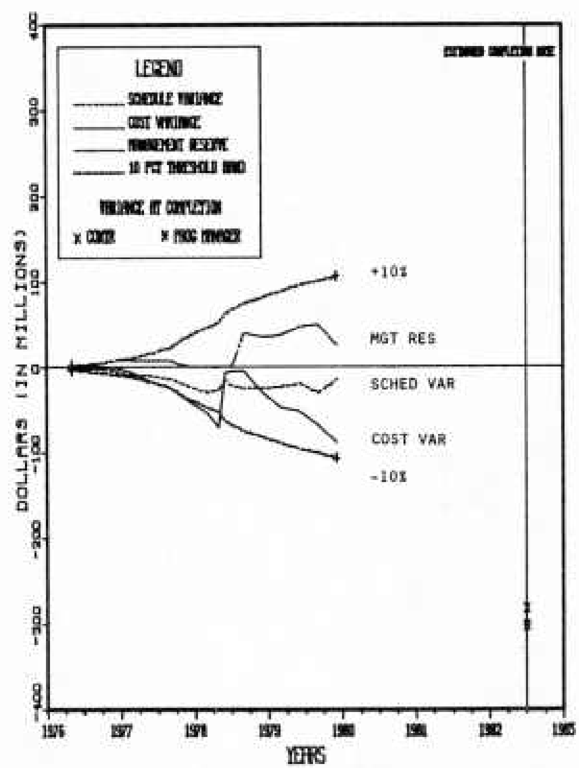


FIGURE 10. UNADJUSTED VARIANCE TRENDS

Compare the slope of the cost line during 1978 to the actual cost variance line in figure 7. Had management reserve not been available, the history of this program might have been quite different. Unfortunately, many programs we follow are not so well managed, and the use of management reserve obscures "actual" cost trends until the effort is in deep trouble.

Returning to our original example it should be noted that the data reflected in figures 4 and 5 have been adjusted from that submitted by the Program Manager. Figures 9 and 10 show the unadjusted data. Comparing the performance and variance charts of the adjusted data (figures 4 and 5) to the unadjusted charts (figures 9 and 10) we see they are the same prior to mid 1978 but differ radically after that time. The reason for this is that budget has been added without a change in contract target cost, thereby creating what is commonly called an "over target baseline." The resulting baseline is "over target" because no change in contract target cost has been made. The amount of the addition is derived from the SCCR (figure 1) by subtracting the Contract Budget Base from the Total Allocated Budget. CPMA adjusts the data in a manner which reorients the Performance Measurement Baseline to the current contract target cost. It is not the purpose of this paper to discuss the reasons or the mechanism for going to an over target baseline, but users of CPR data should be aware of the effects of such an action. An over target baseline builds into the plan an overrun of at least the magnitude of the budget addition and degrades performance visibility. Casual examination of the unadjusted charts (figures 9 and 10) could easily lead to the erroneous conclusion that contract performance is reasonably good. Figures 4 and 5, on the other hand, leave no doubt as to the continuing poor performance on this contract. Furthermore, close examination of figures 9 and 10 shows that there have been no changes in "true" performance trends. The figure 10 cost trend after establishment of the over target baseline parallels the previous trend. Examining the before and after portions of figures 9 and 10 shows that performance relative to the new baseline has deteriorated at the same rate as before the baseline change. It is instructive to note that the SCCR (figure 1) indicates that efforts are currently underway to rebaseline again, thereby perpetuating the illusion of satisfactory performance on this development effort.

Based on information generated by CPMA and the AMID analysts' program knowledge derived from participation in DCP, CAIG, and DSARC activities, Selected Acquisition Reports, and other sources, a final contract summary is prepared (figure 11). The summary plus the performance charts in figures 4 and 5 are then forwarded to the USDR&E in the Major Systems Cost Status Report.

CONTRACT PERFORMANCE SUMMARY

(DOLLARS IN MILLIONS)

SYSTEM: RB-1 REPORT PER1OO: NOV79

OESCRIPTION: AIR 8AG OEVELOPMENT
CONTRACT NO./TYPE: XYZ; CPIF/AF
CONTRACTOR: AMERICAN OIRIGI8LE
REPRESENTS: 72% OF FULL SCALE OEVELOPMENT

		DOLLARS	PERCENT
A.	8UOGETEO COST FOR WORK SCHEDULEO(8CWS):	$940.7	79%
8.	8UOGETEO COST FOR WORK PERFORMEO(8CWP):	$928.6	78%
C.	ACTUAL COST OF WORK PERFORMEO(ACWP):	$1,150.7	97%
O.	SCHEOULE VARIANCE (8)-(A):	$-12.1	-1%
E.	COST VARIANCE (8)-(C):	$-222.1	-24%
F.	TARGET COST:	$1,185.9	100%
G.	CONTRACTOR'S ESTIMATE AT COMPLETION:	$1,468.0	124%
H.	VARIANCE AT COMPLETION (F)-(G):	$-282.1	-24%
I.	PROGRAM MANAGER'S ESTIMATE AT COMPLETION:	$1,488.0	125%
J.	OASO(C)MS ESTIMATE AT COMPLET1ON:	$1,688.0	142%

REMARKS:

Cost performance deteriorated further during this reporting period as the cost variance increased by $26.3M from $195.8M to $222.1M. In addition, $23.5M of management reserve was used. However, neither the Program Manager nor the contractor changed their estimated costs at completion.

Cost and schedule variances are attributed to excessive manufacturing labor hours at Subcontractor Inc. and increased development test effort required during flight test and avionics test. Increased burdent rates are being reviewed for impact and baseline replanning is in progress to encompass the increase in work scope identified during a recent cost review.

The OASO(C)MS estimate of $1,688M remains unchanged. If current cost performance trends persist, the estimate will be revised upward.

BCWS - THE VALUE OF THE WORK THE CONTRACTOR PLANNEO TO ACCOMPLISH
BCWP - THE VALUE OF THE WORK THE CONTRACTOR HAS ACTUALLY COMPLETEO
ACWP - THE ACTUAL COST OF THE COMPLETEO WORK

FIGURE 11. CONTRACT PERFORMANCE SUMMARY

BEYOND CPMA

The CPMA serves a purpose beyond that of evaluating performance of individual contracts. With data on some 120 contracts, AMID is in a unique position to analyze performance trends as they pertain to different commodities, contract types, program phases, etc. In addition, the bottom-line CPR data is the "proof of the pudding" with respect to the implementation of the Cost/Schedule Control Systems Criteria (C/SCSC) and associated reporting requirements. Where these requirements are not properly implemented, erratic data often provides indications of basic management system deficiencies. Since AMID establishes and promulgates policies for C/SCSC and associated cost performance reporting, use of live CPR data helps in the evaluation of the effectiveness of these policies.

ACKNOWLEDGEMENTS

The author was assisted in preparation of this paper by Mr. Robert Kemps, Director AMID, and Mr. Greg Maust, AMID Program Analyst. In addition, Mr. Maust was responsible for CPMA hardware definition and preparation of all related software.

AFSC'S ACQUISITION MANAGEMENT INFORMATION SYSTEM

WITH EMPHASIS ON MILSCAP FINANCIAL ASPECTS

Kenneth E. Mills and Colonel Arthur R. Ryan

Directorate of Contract Data Systems (AFSC/PMQ)
Operating Location Wright-Patterson Air Force Base, Ohio

ABSTRACT

This paper gives an overview of the Military Standard Contract Administration Procedures (MILSCAP) and shows the segments that Air Force Systems Command's (AFSC) Acquisition Management Information System (AMIS) has working. The article is broken down as follows: What is AMIS? What is the Problem? Why MILSCAP Resistance? How Does MILSCAP Fit in the Acquisition Cycle? What are the MILSCAP Segments? What is the Solution? And, How will MILSCAP Be Implemented?

WHAT IS AMIS?

The AMIS program serves three basic purposes. First, it is the AFSC's response to DOD 4105.64M, MILSCAP. This directive was established to attain a greater degree of simplification, standardization, and automation in the processing of contract, contract administration, related logistics and financial data within the Department of Defense. Second, AMIS requires, processes, and stores contract data for use by all levels of management within AFSC to determine contract status. And third, the AMIS provides the automated support for the Air Force Contract Management Division (AFCMD) disbursing function. The AMIS subsystems contain over 500 computer programs. The system produces over 230 formatted outputs and includes a query capability for use by all management levels. Data is maintained for over 47,000 contracts containing more than 600,000 line items having obligations of approximately $100 billion.

Twelve capabilities or tasks are identified and authorized by AFSC Program Direction as additions to the AMIS program. The design, development and implementation of the 12 tasks will be accomplished as an in-house effort while continuing operation and maintenance on the previously implemented AMIS subsystems. The 12 directed tasks include subsystems for Undefinitized Document Control, Small Business Sources, DD 350 Procurement Action Reporting, and the exchange of data with Air Force Logistics Command and Defense Contract Administration Services (DCAS) using MILSCAP procedures. The system will be expanded to provide for direct inputs by all AFSC organizations. Improvements will be sought in simplified data input methods and in providing on-line validations.

The Program Director has both functional and technical personnel available for accomplishing the AMIS. The organizational approach is contained in a program office structured into two divisions and a program control office, i.e., the Functional Systems Division, the Computer Systems Division, and the Program Control Office.

WHAT IS THE PROBLEM?

As described in the foreword of DOD Manual on MILSCAP, "Various studies have indicated a lack of reliable, timely and accurate contract administration data, or automation of such data within the Department of Defense,"(1:i) For example, a recent GAO report said:

> Too many errors are made in accounting for Defense contracts. From Defense contracts valued at over $100,000 and financed by more than one appropriation, GAO randomly selected 26 contracts totaling about $196 million. The review was limited to these multifunded contracts to determine if accounting deficiencies cited by five Defense audits and studies of multifunded contracts had been corrected. . . . Although the number of contracts selected was small, it entailed 856 financial transactions. GAO identified accounting errors of over 90 million dollars on 286 of the 856 transactions. The high error rate GAO found together with deficiencies reported by Defense internal audit agencies indicate that the total dollar value of contract accounting errors is substantial.
>
> The errors not only affected contract administration by the Contract Administration Services regions but also adversely affected the military services' administrative control over appropriated funds and created problems such as billing errors in managing and accounting for the foreign military sales program.(2:ii-iii)

Also, there have been other reports, such as discussed on page 11 of the GAO report, which identified problems in contract accounting by the military services and the Department of Defense Contract Administration Services Regions (DCASR).

WHY MILSCAP RESISTANCE?

If MILSCAP is such an obvious solution, why has it met with so much resistance in "on again and off again" attempts at implementation? The authors of this article believe that the following reasons have contributed and continue to contribute significantly to this resistance: 1. MILSCAP forces abandonment of current systems and methods and transition to standardization. 2. There is a lack of appreciation by the people involved of the total acquisition process, including contract preparation, administration, and payment. Each of these processes are usually performed by different organizations and each group focuses attention on just their part without looking at the whole system. 3. There seems to be a general lack of appreciation of the need for computers to effectively deal with the masses of data which are encountered and must be interchanged in the contract administration and payment areas.
4. Finally, the computer provides visibility to higher echelons of management on information that was previously closely guarded in manual systems.

HOW DOES MILSCAP FIT IN THE ACQUISITION CYCLE?

The acquisition cycle is normally considered to include the following steps.

1. Approval of requirement
2. Statement of work preparation
3. Purchase request preparation
4. Approval of determinations and findings
5. Issuance of requests for proposal/solicitation
6. Commitment of funds
7. Contract award and distribution
8. Obligation of funds
9. Disbursement of progress payments.
10. Delivery of items/services
11. Processing of DD 250s (Material Inspection and Receiving Report)
12. Final payment
13. Closeout of contract

Steps one through six are known as the pre-award steps of the acquisition cycle. While steps seven through thirteen are the post-award steps. MILSCAP is involved only with the post-award portion of the acquisition cycle. Table 1 (page 4) shows the relationship of each of the MILSCAP segments and the post-award acquisition steps.

WHAT ARE THE MILSCAP SEGMENTS?

There are eight segments of MILSCAP. Five of the segments have been designated by DOD for operational use and three of the segments have been designated for future development. The five segments designated for operational use are discussed next.

Contract Abstracts. (1:Chap 3 and 4)
Purpose: The abstract is a data representation of contract documents in the form of several standard 80 column electronic data processing cards. The objective is to transmit this data to the contract administration activity via data communication methods so that the abstracts arrive for entry into computers used for contract administration and payment.
Players: contract award, contract administration, and contract paying activities.
Financial aspect: The contract abstract plays a key role in the financial processes related to contract administration and payment as it transfers obligated dollars by accounting classification in the amount of the contract from the accounting station to the organization who will pay the contract. For example, obligated dollars are transferred from the accounting station at the Aeronautical Systems Division at Wright-Patterson AFB, Ohio to the AF Contract Management Division located at Kirtland AFB, New Mexico.
Status in AMIS: AMIS is programmed to generate abstracts of contracts and modifications as a by-product of source data automation (SDA) which is used by AFSC's buying divisions and centers to prepare contractual documentation. These abstracts are used internally by AMIS users for those contracts administered or paid by AFCMD. If the Atlanta, Boston, or Cleveland DCASRs administer the contracts, abstracts are sent to these regions. AMIS expects to expand abstracts to the remaining six DCASRs before the end of 1980. The Army sends abstracts of its contracts and modifications to AMIS for its contracts administered by the Air Force.

Shipment Performance Notice (SPN). (1:Chap 5)
Purpose: These notices provide notification of deliveries in machine processible format to the inventory manager or project manager who must be kept informed of deliveries. This delivery notification is necessary so that the due-in-asset systems can be updated for requirement computations and budgeting, advising customers of the status of their requisitions, billing customers, and other important functions.
Players: Contract administration activities, inventory managers, project managers, and contracting offices.
Financial aspect: Input of the DD Form 250 (Material Inspection and Receiving Report) to computers used for contract administration makes it possible to generate SPNs which can be used by inventory and project managers for in-service billing.

Status in AMIS: AMIS is programmed to generate SPNs. Activities with a prefix of M, N, E, F, or J in the SPN recipient activity address code (commonly known as DODAAD code) are excluded with the exception of N00039 (Navy Electronics Systems Command), N00104 (U.S. Navy Ships Parts Control Center), and N00383 (U.S. Navy Aviation Supply Office). Where no SPN recipient DODAAD is shown, the SPN will be sent to the "issued by" DODAAD. Service line items (PJR) are also excluded. It will take AMIS approximately four months to implement the currently exempted SPNs.

Destination Acceptance. (1:Chap 6)

Purpose: As the title indicates, this segment provides procedures for the consignee (e.g., the requisitioning activity) to report acceptance of materiel at its destination rather than at its origin. Acceptance at origin is accomplished by Government quality assurance personnel at the contractor's facility. The procedures also provide for alerting the consignee that the materiel is being shipped and that a destination acceptance report must be made for the disbursement activity to pay the contractor.

Players: DCAS contract administration offices, consignees, and disbursement offices.

Financial aspect: Satisfactory completion of the acceptance alerting and reporting procedures cycle is necessary to complete the financial cycle of disbursing obligated funds received with contract abstracts.

Status in AMIS: AMIS is currently programmed to receive acceptance reports (PKN). AMIS is not programmed to generate acceptance alerts (PK5). As of this writing, DOD has not required the Air Force to implement this area. When directed, AMIS can implement the additional capability within a couple of months.

Contract Payment Notice (CPN). (1:Chap 9)

Purpose: To provide detail payment and collection data back to the designated accounting point specified by the department or agency whose funds were cited in the contract and sent to the contract administration and payment activity as a part of the contract abstract. These notices provide the basis for determining status of the obligated funds included in the contracts and abstracts.

Players: Contract administration offices, disbursing offices, and accounting activities of the department or agency.

Financial aspect: The CPN was designed to provide financial payment data back to the designated accounting activity whose funds were included in the contract and abstracts.

Status in AMIS: AMIS does not currently have a CPN capability because this area has not received a high priority for DOD development. AMIS is currently developing a CPN capability and just started receiving CPN records from the Security Assistance Accounting Center (SAAC). The capability to update with these records will be completed in approximately one month. This does not include internal automated checks and balances which are needed. However, these will be completed by the time this segment is ready for implementation. Nine months will be required to develop a CPN generation capability including automated checks and balances.

Contract Completion. (1:Chap 11)

Purpose: To provide the status of unclosed contracts after the contract is physically (performance) completed. This segment specifically covers major events of physical completion, timeframes for closing contracts, final payment, and contract closure. Also, included in this segment are provisions for the contracting office to notify the contract administration office that the closeout date has been extended.

Players: Contracting offices, contract administration offices, and disbursing offices.

Financial aspect: This segment is closely tied to financial processing because the voucher making the final payment starts the process of contract closure. Also, the closing of the contract process causes the removal and return of any excess funds.

Status in AMIS: AMIS has implemented this segment with the exception of the PKZ (contract closeout extension) record which will require five months to develop after DOD standardization of this area.

Next, the three segments designated by DOD for future development are summarized.

Revised Delivery Forecast. (1:App G)

Purpose: This segment will provide the contracting office, inventory manager or project manager actual or anticipated deviations from the delivery schedules included in the contract and contract abstracts. If the schedules are for items requisitioned by customers using DOD Military Standard Requisitioning Procedures (MILSTRIP), the revised forecast data would include information required for the preparation of status responses to the customer.

Players: Contract administration offices, acquisition managers, and contracting offices.

Financial aspect: None.

Status in AMIS: Undeveloped at this time.

Contract Line Item Status. (1:App J)

Purpose: This segment will make it possible for the inventory manager or project manager to request from the contract administration office the status of contract line items. The use of these procedures will be limited to potential work stoppages, urgent requirements, and other conditions which are not classified as routine.

Players: Contract administration offices, inventory managers and project managers.

Financial aspect: None.

Status in AMIS: Undeveloped at this time.

Disbursement Reporting. (1:App H)

Purpose: This segment will provide for the contract administration office to transmit summary disbursement data to a central accounting office designated by the departments and agencies.

Players: Disbursement offices, contract administration offices, and designated accounting activities.

Financial aspect: This segment is completely in support of designated financial management activities within the departments and agencies which forwarded their funds to disbursing offices serving the contract administration offices.

Status in AMIS: Undeveloped at this time.

Table 1. This table shows the post-award acquisition steps and the corresponding MILSCAP operational and future segments.

when necessary, to ensure timely, effective implementation. (2;iv)

HOW WILL MILSCAP BE IMPLEMENTED?

The GAO report recommended the DOD establish implementation milestones for the MILSCAP. The Defense Logistics Agency (DLA) as executive agent for MILSCAP, by letter March 28, 1980, required each of the military services and the DOD Contract Administration Services (DCAS) to establish implementation milestones for their respective activities. Specifically, the military services and DCAS were required to provide implementation target dates for the five operational segments of MILSCAP: Contract Abstract, Shipment Performance Notice, Destination Acceptance, Contract Payment Notice, and Contract Completion. The other three segments

Table 1. Relationship of Post-Award Acquisition Steps to MILSCAP Segments

Post-Award Acquisition Steps	Operational MILSCAP Segments	Future MILSCAP Segments
7. Contract award and distribution	Contract Abstract	
8. Obligation of funds	Contract Abstract	
9. Disbursement of progress payments	Contract Payment Notices	
10. Delivery of items/services	Shipment Performance Notice/Destination Acceptance	
		Revised delivery Forecast
		Contract Line Item Status
11. Processing of DD 250s (Material Inspection and Receiving Report)	Shipment Performance Notice/Destination Acceptance	
12. Final payment	Contract Payment Notices	
		Disbursement Reporting
13. Contract closeout	Contract Completion	

WHAT IS THE SOLUTION?

The solution as recommended by the January 1980 GAO report is for the Secretary of Defense to:

> Require the Defense Contract Administration Services Regions to assure the accuracy of the financial transactions processed and sent to the military services. Require the implementation of MILSCAP in all Defense systems involved with contract accounting and management, and direct the Assistant Secretary of Defense (Comptroller) to require specific timetables from the military services on implementation dates for the MILSCAP. The Comptroller also should actively monitor the implementation and require corrective action,

in the MILSCAP manual are identified for future development; namely: Revised Delivery Forecast, Contract Line Item Status, and Disbursement Reporting. These eight segments were discussed in greater detail previously in this article.

The DOD MILSCAP Administrator and the focal points for the military services and DCAS have not jointly agreed to common implementation dates as of the writing of this article. Based upon past experience, several working group sessions will be necessary to hammer out implementation milestones. Also, additional work will be needed to revise internal contracting, contract administration, and financial regulations. Meetings of the Joint Logistics Commanders offer an ideal platform from which unified implementation action could be

launched and monitored.

In conclusion, there is a great need for the military services and DCAS to develop and implement an automated capability to exchange contracting and financial data to increase standardization, accuracy, and timeliness of forms preparation and to reduce abstracting workload. Mechanization of these processes forms a basis for improved communications and status reporting. The interchange of data including the use of query techniques reduces manual reporting, makes current data available for management decisions, and reduces significantly letters and telephone calls requesting data. AFSC's AMIS has a good start toward these MILSCAP efforts which will increase the efficiency and effectiveness of the weapons acquisition process.

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SESSION 15

COMPETITION

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EVALUATION OF COMPETITIVE ALTERNATIVES FOR WEAPON SYSTEM PRODUCTION

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ABSTRACT

This paper describes a model for analyzing alternatives concerning competition in the production phase of a weapons system. The model applies to the multi-period production of systems for which high costs of introducing and sustaining competition offset the effect of competitive forces. The model includes the effects of learning, capacity constraints, and costs of layaway, reactivation, start-up, direct production, etc. The strategies available include sole-source, full competition, or limited competition. A numerical example is presented, and the applicability of the model is discussed. Non-price aspects of the competition decision are not treated in this report.

INTRODUCTION

One of the many significant decisions faced when acquiring a major weapon system concerns the issue of competition. Should the production phase of the system acquisition be competitive, and, if so, what form should the competition take? For some systems the difference between a right and a wrong decision on these questions means $100 million or more. In this paper an approach is presented that provides insight into the scope and impact of the competition decision. The methodology arose from the attempt to apply previous empirical findings in the context of a specific missile system project. The available data were an insufficient guide to decision-making, and it was necessary to construct a model to serve as a decision framework for the data.

I attempt in this paper to convey three principal ideas. First, a useful model for analyzing competition questions has been developed. Second, the constraints on the practical use of the model are not severe. Third, the model points to areas requiring improved empirical findings.

Basically, the model considers the long-term cost effects of different competitive choices for a system given a stream of annual production requirements. The model formalizes cost trade-offs existing between competitive forces of the marketplace and cost increases from sources such as establishment of more production facilities. Traditionally, naive rules of thumb have been applied in determining the competition decision. Sometimes, with little justification, reductions of fixed percentages of total cost have been assumed to result from competition.

Recently researchers have begun to examine these trade-offs. Empirical studies estimating the reduction in unit costs attained from introducing a competitive environment have been reported by Burt and Boyett [1], Lovett and Norton [2], and Daly et al. [3]. These studies suggest that 10 - 40% reductions in recurring costs per unit may typically result when competition is introduced into a sole source supplier situation. The empirical data tends to be highly variable. Special circumstances of a given acquisition situation may dramatically alter the savings expected. Yet these studies provide some guidance for the necessarily judgmental estimate of the effect of competitive intensity on unit costs.

Reduction in unit recurring costs is not sufficient to justify competition, however. Systems are often acquired over multiple contract award periods, and maintaining a competitive environment over several contract periods has its own expenses. Thus, in general, the decision is not limited to a choice between a sole source and a single buy-out competition for all remaining production. One may, therefore, need to consider the competitive environment that will exist when a future contract is awarded.

Non-price aspects can be quite important in making the competition decision. For example, a split-award using two producers may be desired to increase reserve capacity. Since the model developed here does not treat non-price considerations, it should be considered as only one part of a full decision analysis.

METHODOLOGY

<u>Model Description</u>. The setting of concern to us is the production of large quantities of complex items such as tanks or missiles. Because the end-items are so specialized and complex, substantial costs will typically be incurred by introducing competition. For example, additional tooling and learning buys may be required. Also the quantity to be purchased is typically large enough that production requirements can extend over more than one contract performance period.

For such systems the learning curve exerts an important influence on expected system costs. For these systems the original producer is usually the system developer. While production output is still low, a second source can be educated (by the use of small buys) in order to reach a level of competitiveness with the original producer.

The preceding tends to justify a major limitation of the present model which is that only two producers are considered. It is assumed that if a second source is used, it will be ready at the beginning of the first period of time considered by the model. Finally, if the potential second source is not maintained, then awards for all future time periods will be sole source.

The competitive production alternatives treated by the model are stated below:

1. Sole source -- The system developer becomes the sole source producer. Alternatively, periods of competition are held, but eventually one firm becomes sole source for buys in subsequent periods.

2. Buy-out -- A second source is developed. After the second source has demonstrated its capability, a buy-out competition results in the award of all current period requirements to the lowest offeror from the two sources.

3. Split-award -- A second source is developed, but both producers are retained by making split awards. The government retains the right to award the lowest cost producer with a larger percentage of the buy.

4. Layaway -- One of the sources is not used during a contract period, but the equipment is maintained so that the potential for a second source continues.

Again note that in the model the choice made in one contract period affects the possible choices in subsequent periods. For example, a buy-out in period one precludes the possibility of a split-award in period two unless the second source is placed on layaway during period one.

Several other features reflected in the model are now stated. It is likely that the primary competitive decision will be needed prior to the identification of both of the potential sources. Therefore, it is assumed that both of the potential producers are equal in terms of efficiency and capacity. Production output rates that are above or below specified values result in increased unit costs. The lines also have maximum and minimum output levels within which production must lie. A key assumption of the model is that the intensity of competition surrounding a particular acquisition affects the unit price. Unit price level for an award is affected by the number of available sources and the price level set by the degree of competitive intensity in the prior period. In the case of split awards the competitive intensity is affected by the minimum award percentage expected by the contractors. The learning curve is incorporated in the model to deal with the accumulation of contractor experience. Since the production awards considered will typically be large, concern for securing work in the future time periods is assumed to have negligible impact on current period contract price behavior. That is, the contractors are assumed to "bid honest" rather than "buying in" with an unjustifiably low bid. Finally, it is assumed that multi-year awards can be made.

The general mathematical statement of the model equation and constraints is quite complex and is summarized in the appendix. Let it suffice to say that the total costs for a contract award period are a summation of product costs (fixed and variable), and costs of layaway, maintenance, and reactivation of lines (if appropriate). All costs represent costs to the government and therefore include the contractors' fees. As indicated above, product costs are dependent on the degree of competition present during the pre-contract award phases. The notational complexity arises from the specific forms of the various cost functions needed to make them compatible with the several features described earlier. The optimum sequence of competitive or non-competitive alternatives minimizes the total discounted cost over the entire time interval for which production requirements exist. A computer program has been written to solve the problem described above by a dynamic programming approach.

Example. In this section the model is applied to a numerical example. The example also shows how the optimum choice of an acquisition strategy can change with alterations in the requirements flow. In applying the model it is necessary to estimate the values for several parameters. These parameters include the initial costs for establishing the required number of producers, the minimum and maximum annual production rates attainable by a single producer, the cost penalties for annual production outside of an efficient range, the discount rate, the estimated unit variable cost under full competition, the learning curve slope, etc.

In addition to these parameters it is necessary to estimate a penalty factor (expressed as a percentage of the fully competitive unit costs) for various deviations from a fully competitive situation. For example, we might estimate 15% as the penalty factor for sole-source following another non-competitive period but only 10% for sole source showing a residual effect from prior period competition.

A projected production requirements stream is displayed in Table 1. This situation was analyzed using parameter values considered plausible for a hypothetical missile system. The recommended strategy was successive buy-out competition for each contract award. Some of the alternatives and their percentage deviation from the optimum are displayed in Table 2.

Table 1. Requirements Stream

Contract Period	Year	Output Units/Year
1	1	18000
1	2	18000
2	1	18000
2	2	18000
3	1	18000
3	2	18000
4	1	18000
4	2	18000
5	1	14000
5	2	10000
TOTAL		168000

Table 2. Results

Initial Decision	% Cost Above Minimum	Optimum Sequence
BO	Minimum	BO-BO-BO-BO-BO
SS	13%	SS-SS-SS-SS-SS
SA	2%	SA-BO-BO-BO-BO

where BO = buy-out, SS = sole source, and
SA = 75% - 25% split award

The requirements from Table 1 were then increased by 28% in each of the first eight years. Under such projected requirements growth the preferred initial strategy becomes a split award. In fact the model predicts a 60% - 40% split award in the first period will be optimal. The projected percentage split is important because it impacts the cumulative experience gained by the contractors. In this case the presence of increasing cost penalties as maximum capacity is approached has overcome the benefits of the greater competitive force present in a buy-out situation.

Applicability. Several important questions can be raised regarding the applicability of the model. It is my claim that the limitations to practical use of the model are not severe.

Parameter estimation is an important consideration. Indeed a large number of parameter estimates are required. It is felt, however, that the project management office and the developing contractor will be able to provide increasingly reliable data as the required decision time approaches. Further, sensitivity analysis is necessary anyway and will often show that the optimal decision is relatively stable to sizable changes in most of the parameters.

A given situation may require changes to the basic model formulation. Some changes, such as a change to the objective cost function, ought to be easy to implement. This is because the basic structure of the solution algorithm is not altered.

Some possible changes, however, have a fundamental impact on the model. An example of such a change would be an expansion to accommodate more than two producers.

A complex model needs some justification of its complexity. Two points are made in this regard. First, the decision considered here is made only once per applicable system, but the impact of the decision is quite substantial. Therefore, the decision is worthy of detailed analysis. Secondly, the empirical work performed so far reveals a great variability in the response to competition. This variability suggests that the analyst must seek additional insight by examining the details of the particular system being studied.

The greatest limitation to the use of the model is the need to estimate a competitive intensity penalty factor. It is here that the decision-maker must balance current empirical results with personal judgment. At the present time empirical research can only suggest a rough average value for the effect of competition on unit costs. Yet the decisions must be made, and the factors identified do influence the correct decision.

Thus there remains a real need to better define and quantify the mechanism by which competition exerts its influence on weapon system costs. It is recommendea that future work focus on this empirical documentation of the effect of competition. For example, does competition exert its influence by altering the learning curve slope, or does it work through a one time "squeezing-out" of a fixed percentage of unit costs?

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APPENDIX

Model Summary. In order to describe the model mathematically the following notation is used:

j = index for the production facilities (contractors) in use

n = index for the time periods (contract award periods) in the planning horizon

N = the number of time periods in the planning horizon

x_n = variable representing the number of producers with a contract award in period n

$y_{j,n}$ = variable proportion of the total production requirement for period n awarded to producer j

y_n = variable denoting $\max_j \{ y_{j,n} \}$

z_n = variable denoting the number of producers available for awards at the beginning of period n

m = minimum production rate for a producer

M = maximum production rate for a producer

$I(z_1)$ = initial costs incurred in order to establish z_1 producers at the beginning of period 1

Q_n = maximum cumulative production quantity attributable to a single producer through period n (Depends on production history prior to period n. Used to account for improvements in cost due to experience).

$D_n(x_n, y_n, z_n, y_{n-1}, z_{n-1}, Q_{n-1})$ = function measuring the standard product costs incurred in period n using x_n producers with y_n maximum percentage to a single producer; with a competitive environment described by y_{n-1}, and z_{n-1}; and with experience level measured by Q_{n-1}.

$P_n(x_n, \{ y_{j,n} \}, z_n, y_{n-1}, z_{n-1}, Q_{n-1})$ = function measuring penalty product costs incurred in period n due to production volume outside the efficient capacity region

$V_n(w)$ = costs incurred to reactivate w facilities

$L_n(w)$ = costs incurred to layaway w facilities

R_n = production requirement in period n

Then the general problem can be stated as follows:

$$\underset{\{(x_n, y_n, z_n): 1 \leq n \leq N\}}{\text{Minimize}} \quad I(z_1) + \sum_{n=1}^{N} [D_n + P_n + V_n(\max(x_{n+1} - x_n, 0)) + L_n(\max(z_{n+1} - x_n, 0))]$$

where we require

$$z_{N+1} = z_N = x_N = x_{N+1};$$

$$x_n \leq z_{n+1} \leq z_n \text{ for } 1 \leq n \leq N-1;$$

$$m \leq y_{j,n} R_n \leq M \text{ for } 1 \leq j \leq x_n,\ 1 \leq n \leq N, R_n > 0;$$

$$x_n,\ z_n\ \varepsilon\{0,1,2\} \text{ for } 1 \leq n \leq N;$$

$$x_n = 0 \text{ if and only if } R_n = 0 \text{ for } 1 \leq n \leq N;$$

$$\sum_{j=1}^{x_n} y_{j,n} = 1 \text{ for } x_n > 0;$$

$$Q_n = \sum_{i=1}^{n} y_i R_i \text{ for } 1 \leq n \leq N;$$

$$\text{and } x_0 = y_0 = z_0 = Q_0 = 0$$

In order to completely define the model specific cost forms must be specified for D_n, P_n, L_n and V_n. The complete specification of these functions in a manner consistent with the assumptions of the report requires further notation and is not presented here.

FORECASTING SAVINGS FROM REPETITIVE COMPETITION WITH MULTIPLE AWARDS

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ABSTRACT

Early in the acquisition cycle program managers and contracting officers must decide whether or not to compete the remaining quantities of a weapon system. There can be substantial one-time costs to introduce competition, and there can also be savings in unit price. Previous studies have addressed winner-take-all buyouts. This study considers the possibility of multiple (or split) awards, and also considers repeated competitions for the same item. Competition reduces the unit price by an average of 7% in the present sample.

OBJECTIVES

The objectives of this study are to: (i) develop a methodology for estimating the competitive savings where there is a sequence of acquisitions and where multiple awards can be used, (ii) exercise the methodology on a sample of acquisitions, (iii) develop a forecasting methodology for use with future acquisitions.

STUDY APPROACH

In order to accomplish the study objectives the literature on competition was reviewed. Ammunition items were selected to illustrate the type of competition being studied. Interviews were held at Picatinny Arsenal and at Rock Island to clarify the types of competition used in the acquisition of ammunition. A list was made of items that had been purchased competitively. Price and quantity data and other relevant information were collected from contract files. Other data sources included cost analysis studies and interviews with the contracting officers.

A sample of 22 acquisitions was selected for analysis. The selection was based on the desire to reflect the diversity of ammunition items and to perform a longitudinal analysis of a sequence of acquisitions for the items selected. Before each acquisition there were one or more incumbent contractors already producing the item, and as a result of the acquisition one or more contractors (possibly different ones) received competitive awards.

Data for each contract were adjusted. Nonrecurring costs were subtracted, prices were converted to constant FY 1978 dollars using price indices, and midpoints were calculated to allow further adjustment for learning, as described more fully below. A methodology was developed to estimate the savings in unit price attributable to competition. Finally, factors which could explain these savings were analyzed. It was necessary to make several assumptions in the analysis. These assumptions relate primarily to how the noncompetitive awards would have been made and to the expected rate of learning. The assumptions will be described as they are made.

POPULATION AND SAMPLE

The target population is defined as all competitive acquisitions for ammunition items which are in the production phase of their life cycle and which are produced by private contractors in contractor-owned plants. An acquisition is considered competitive if any contractor can bid or if bids are restricted to members of the mobilization base. In some acquisitions the government announced that a winner-take-all award would be made, while in others the government stated in advance that at least some members of the mobilization base would receive awards (without specifying which members). Both approaches are competitive. Considered not competitive are options, which are part of the previous contract, and add-ons, in which the government modifies an existing contract to award an additional small quantity to a current producer.

The term "ammunition" includes bombs, fuzes, projectiles, cartridge cases, warheads, and other items. While the items vary, the acquisitions for these items are similar in several important ways. First, contractors for these systems operate within the same mobilization base environment. Second, all items are in the production phase. They offer low technical risk, as evidenced by the use of fixed-price (firm-fixed-price or fixed-price with escalation) contracts. The risk in many acquisitions is even less, because the contractors have already produced millions of the item.

The main variable of interest in this study is the savings in unit price attributable to competition,

after accounting for the effects of non-recurring cost, learning and inflation. This study seeks to quantify the savings due to the government's act of entering the marketplace, as opposed to, say, using add-on contract modifications with the current contractors. Other variables which could explain the main variable savings were also constructed. Examples include the relative size of the acquisition, the competitive pressure (measured in several ways), the number of the acquisition (first, second, etc.) and others. First will be described the calculation of the competitive savings variable and then the other explanatory variables will be described.

The sample of twenty-two acquisitions was selected to reflect the diversity of the population. Six acquisitions were observed for bombs, four for fuzes, nine for projectiles, and three for cartridge cases. The acquisitions were also selected to illustrate long sequences of purchases for the same item in order to determine whether or not the benefits of competition diminish in later acquisitions.

The sample, like the population, shows some instances of winner-take-all competition and other cases where multiple awards were used. All acquisitions in the sample reflect production contracts. No research and development contracts were analyzed.

No attempt was made to select "successful" competition, i.e., contracts which result in savings; however, in each case government officials had concluded prior to the acquisition that competition was possible. Thus, any findings developed in this study apply only to situations in which competition would normally be considered, and not to all acquisitions.

ESTIMATED SAVINGS METHODOLOGY

The ideal approach for estimating the effects of competition would be to find a competitively awarded contract and compare it with one that had been awarded without competition. To make the comparison valid, the two contracts should be as similar as possible. In practice, however, if the government's contracting situation were similar in both situations, then both would have been awarded the same way, and no comparison would be possible. For every competitive acquisition it becomes necessary to construct a hypothetical control, or point of comparison, to reflect what would have happened if the requirement had been satisfied noncompetitively.

The literature shows a series of gradually more sophisticated attempts to construct this hypothetical control. One approach has been to take as the experimental control the unit price for the most recent sole-source contract. This sole-source price is then compared with the price observed after a competitive award and the drop attributed to competition. This approach, however, fails to consider the progress of the sole-source producer along his experience curve and thereby overstates the benefits of competition. Figure 1 shows this approach and Figure 2 shows the required adjustment.

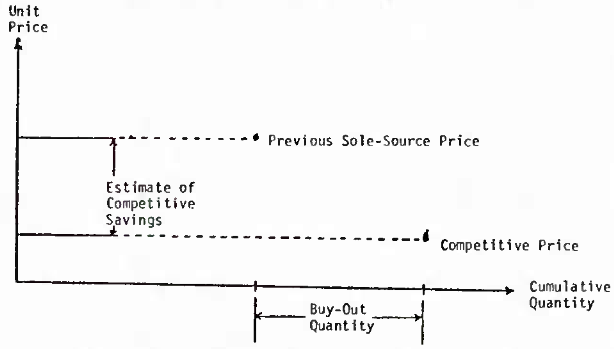

Figure 1. Simple Estimate for Competitive Savings

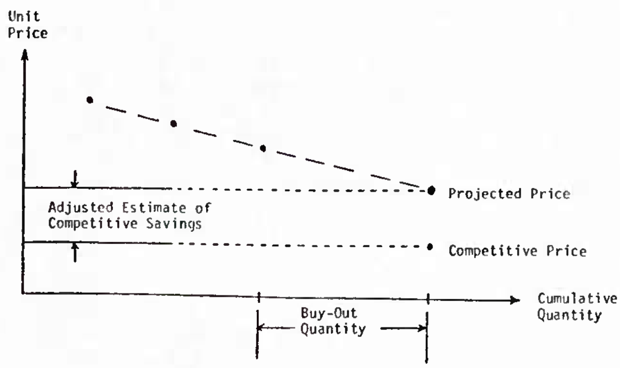

Figure 2. Adjusted Estimate

Lovett and Norton developed(1) an improved methodology which takes into account the expected progress of the first producer along his experience curve. Figure 3 illustrates the basic methodology. The dotted line reflects what would have happened had there been no competitive pressure--the contractor simply would continue along his experience curve for the quantity of the buyout. The dotted line in this case serves as the experimental control. The actual contract price is shown as a solid line for the same quantity. In Figure 3 the solid line is shown as horizontal because contracts for the buy-out quantity are usually awarded as fixed-price contracts, and no experience slope is visible to the government. The area between the dotted line (would-have-paid) and the solid line (did pay) is attributed to competition.

Several extensions to the Lovett and Norton approach are necessary to address repetitive competition and the use of multiple awards. First, there is rarely a buyout. Instead there is a sequence of current requirements. Second, the effects of contractor learning are not visible to the government since most awards result in fixed-price type contracts. Third, there are usually several producers both before and after a given acquisition. While unit prices (in

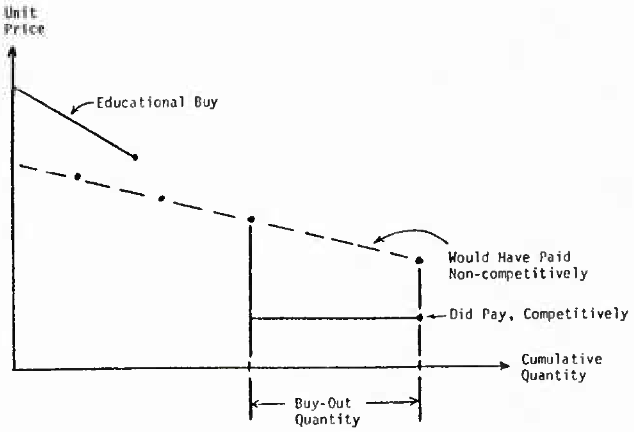

Figure 3. Lovett-Norton Estimate of Savings

constant FY 78 dollars) clearly decline over time, this decline results from many factors including (1) learning curve progress, (2) the effects of competition, and (3) the actual portions awarded to each contractor before and after the competition.

Other factors in addition to learning, competition, and the portions awarded can change the price. Value engineering, technology breakthroughs and changes in product quality can reduce the price of the item being manufactured. Producers using equipment already paid for may not experience inflation at the same rate as the price indices imply. Allocation of fixed costs can vary from one award to the next. It is possible that a change in price (up or down) occurs due to the acquisition act itself, i.e., the fact that the government has entered the marketplace again. It was not possible to quantify the possible influence of these factors in the present study. After adjusting for nonrecurring cost, inflation, and the portion awarded, this study attributes the change in price to contractor learning and competition.

Figure 4 illustrates the savings methodology. It shows the special case where one producer has won every award for a sequence of three competitive acquisitions and is now the incumbent. The situation of several incumbents is discussed below. In Figure 4 the recurring unit price (in FY 78 dollars, and excluding one-time costs) is plotted against the cumulative quantity awarded to this producer. The solid horizontal lines show the unit prices paid by the government during each award, and the dotted lines show the prices for each individual unit (known to the contractor but not known to the government). The algebraic midpoints of each award are indicated by dots.

The reduction in award price reflects both learning and competition. In order to separate the effects of these two factors it is necessary to know something about the learning curve slope. Very little information is available about learning curve slopes in the ammunition industry, possible because of the extensive use of fixed-price contracts in which contractor learning exists but is not reported. Government contracting personnel report that there is very little learning due to the highly automated production techniques and the large quantities involved. Cost analysis personnel indicate that slopes range between 90 percent and 95 percent (cases 94.3 percent, projectiles 92.6 percent and fuzes 91.1 percent).

The steeper 90 percent slope attributes a greater portion of the price reduction to the effects of learning. This minimizes the portion of the reduction attributed to competition. The flatter 95 percent slope attributes less of the drop to learning and more to competition. A 100 percent slope would imply no learning at all. In this case the entire drop would be attributed to competition. In view of the uncertainty about the slope all calculations are made using the three slopes 90 percent, 95 percent and 100 percent.

To calculate a projected price for what the government would have paid using multiple noncompetitive add-ons, it is necessary to make some assumptions about how the total new requirement would be split among the incumbents. The assumption usually made in this study is that the awards would be split into the same proportions as are observed in the previous awards. Each incumbent is operating at a different point on his learning curve, so a projected price is calculated for each contractor, based on his assumed portion. The results are combined to give a composite projected noncompetitive price for the total acquisition. This projected price reflects the learning achieved by each contractor and estimates what the government would have paid using noncompetitive add-ons. The difference between the projected noncompetitive price and the actual competitive price is attributed to competition.

For each of the 22 observations in the sample the projected noncompetitive price was calculated. The actual competitive price was subtracted and the difference, representing competitive savings, was expressed as a percent. The average savings in unit price, assuming a 95 percent slope was 7.1 percent. Slopes of 90 and 100 percent imply savings of 3.7 percent and 10.0 percent, respectively.

A multiple regression analysis was performed to determine what variables may increase or decrease the effect of competition on unit price. Variables considered were (a) award number (first, second,. . .) for the acquisition, (b) number of incumbent contractors before this acquisition, (c) number of contractors after awards are made, (d) competitive pressure, defined as the number of contractors before award divided by the number after, (e) quantity awarded. None of these variables can account for the variation in savings observed. The data for this analysis is given in Brannon, Burns and Neely(2).

In this sample, the competitive savings achieved in later acquisitions is approximately the same

as the savings achieved in the first few acquisitions for the same item. This unexpected finding should be verified in future studies.

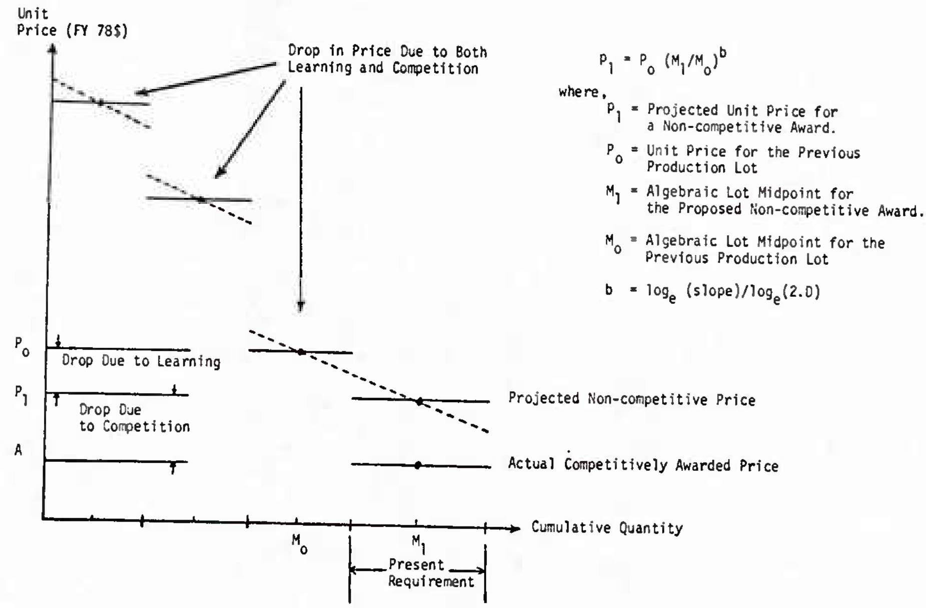

Figure 4. Estimated Savings Methodology

In conclusion, a useful rule of thumb is that competition with split awards reduces the unit price by an estimated 7 percent. This figure can be used in a tradeoff analysis to determine the economic effects of introducing competition, which in some cases can require large one-time costs.

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COMPETITION IN DEPARTMENT OF DEFENSE ACQUISITION

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ABSTRACT

In recent years questions have been asked by the Congress, the General Accounting Office, and others relative to the large number of government contracts which are awarded on a sole-source basis. The purpose of this paper is to examine the circumstances which structure this situation. A point of departure will be the economic concept of the market and market structures. From a placement methodology standpoint the government places contracts either through advertising or negotiation. In general, the advertised methodology occurs in the pure competition, monopolistic competition, and oligopoly market structures. As the market and the product becomes more specialized, negotiation as a placement methodology is used. Several government practices will be examined in the paper. Research has been conducted that examines several of these government practices. This research will be examined in the context already established for this study.

INTRODUCTION

In recent years questions have been asked by the Congress, the General Accounting Office, and others relative to the large number of government contracts which are awarded on a sole-source basis. For example in FY 1978 the percentage of non-competitive awards was 62.4 percent while 37.6 percent were awarded on a competitive basis.(1) The purpose of this paper is to examine the circumstances which structure the environment for DOD acquisition. The concept of competition, market structure, contract placement methodologies, the competitive environment, and current research results as they impact on competitive conditions will be discussed. A starting point for the analysis is an examination of the concept of competition.

COMPETITION

The term "competition" is an underlying thread which runs through all aspects of the US economy. It is a word that is not necessarily easy to define except in the context of a given situation. Webster gives two basic meanings for the word. One meaning is general and the other has an economic connotation.(2) In the general sense, competition deals with a struggle between individuals or groups for some goal, resource, or other objective. The Durants state that this struggle is either peaceful or violent depending on the objectives.(3) In the context of population and food, for example, in times of plenty, the competition is relatively peaceful but conflict ensues as individuals and groups vie for their perceived share. In times of scarcity, the competition tends to become more intense. The Durants summarize this concept by stating that competition is the first biological lesson of history. Darwin acknowledged competition in life as the struggle for survival.(4)

The economic interpretation of competition focuses on the struggle for a share or shares of limited resources. Adam Smith brought the concept into perspective by relating trade and individual self-interest to the market for a specific good. He stipulates that an "invisible hand" will regulate the supply and demand for a good by establishing a price which will clear the market of all goods in a given time period.(5) Smith postulated that competition was good and that each individual or group in seeking its own goals would thereby promote the best condition for all of society. The regulating force in society then was competition.(6) However, this system regulated by competition was one where power to control price was diffused. No one firm as a seller or individual buyer could influence price, rather price was accepted in a specific time period as a given determined by the interaction of market supply and demand.

As early as 1932, a study by Berle and Means found that corporate wealth rather than being diffused and shared by many small firms was increasingly being concentrated in the hands of a relatively limited number of companies.(7) Their study revealed that over fifty percent of all corporate wealth was concentrated in approximately two hundred companies. This trend has continued unabated, so that today over eighty percent of all corporate wealth is concentrated in the hands of twenty percent of the US corporations. This factor has significance when the concept of competition is evaluated in the context of today's marketplace. Concentration of wealth gives large corporations control over price. No longer does the market determine a market price in the majority of cases, rather corporate officials who produce and sell their products in a sole source (monopoly) situation

develop prices which may or may not reflect cost plus a reasonable return. To place this situation in perspective, market structures must be examined.

MARKET STRUCTURE

Economic theory posits a range of market structures as illustrated in Figure 1. At one extreme is pure competition (perfect competition-a highly abstract concept will not be considered).

PERFECT COMPETITION	PURE COMPETITION	MONOPOLISTIC COMPETITION	OLIGOPOLY	DUOPOLY	MONOPOLY

Figure 1. Market Structure Spectrum

In pure competition the product is standard or homogenous in nature and there are many firms which can supply the product to the many buyers who compete for the available supply. The market is characterized by resource mobility and the abundance of and accessibility to market information. No one firm or buyer has the ability to influence price, rather it is set by the market. This was the market structure which Smith envisioned as being beneficial to society. Today it exists in modified form for some agricultural, mining, and standard equipment components. The key is that the market in the absence of collusion among sellers will deliver the lowest and best price to the buyer in terms of efficient resource use and allocation.

For the monopolistically competitive market, there are fewer sellers with many buyers. Each seller, in order to acquire and maintain market shares, seeks to differentiate his product in the minds of the buyers by advertising or product redesign. The structure is characterized by excess capacity. The best examples of this market structure are fast-food restaurants, appliance and furniture dealers, and various service firms.

The oligopoly structure consists of many buyers and few sellers. The products are basically similar in terms of form, fit, and function; however, the firms attempt to differentiate their products by advertising. Two basic conditions exist; the firm may practice market segmentation or product specialization strategies. The market is usually dominated by one large firm which establishes and maintains control over price. In some segments of this market structure, the firm may essentially operate as a monopolist with complete control over price. This market structure is illustrated by the oil, automobile, tire, and other similar industries.

Duopoly is basically an artificial structure characterized by two sellers for a given product. One of the firms is usually dominant and has control over price and industry operation. As such, the larger firm is usually capable of driving the smaller one out of business, therefore, about the only way that a duopoly can exist over time is by virtue of government intervention. Thus, the earlier statement that this market structure is artifical. Several situations have occurred in the past where the government has established a duopoly situation by providing an existing firm with technical data or setting up a firm to produce a product in competition with an existing firm. Examples include constant speed drives and rifles.

Monopoly represents the other extreme of the spectrum where only one firm exists to provide the market with a specific good and has a high degree of control over price. Other than for regulated monopolies, such as telephone, electricity, natural gas, etc., pure monopolies are illegal, however, product specialization and market segmentation enable some firms in a sole-source situation to act as monopolist.

A specific firm, especially one of the larger ones, in the Department of Defense (DOD) market probably manifests several faces to the government: at times bidding and selling competitively. At other times some more or less monopolistic approach is taken, while some firms may specifically sell to the DOD in a strict market structure sense, such as pure competition, etc. Several attempts have been made to classify the government marketplace. One approach has been to characterize it as a bilateral oligopoly where several government agencies for a given product interact in a market with a few sellers.(8) One other significant approach is to characterize the market as a bilateral monopoly where a monopsonist (the government) buys from a monopolist (one firm) at a time for a given product. This latter structure is probably most appropriate based on market segmentation and product specialization. In order to verify this condition, the need is to examine the manner in which the government buys--an examination of the applicable placement methdologies.

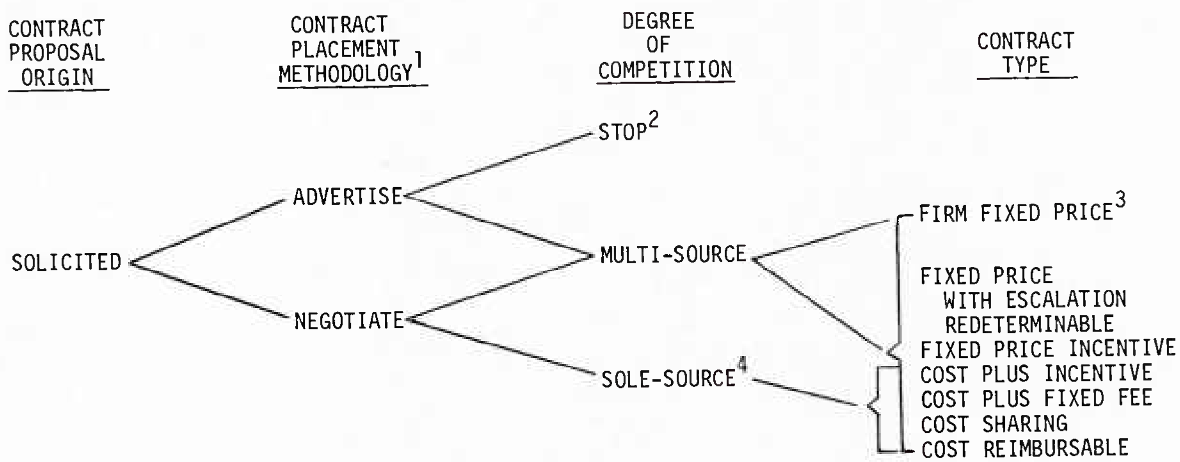
PLACEMENT METHODOLOGIES

Placement methodology refers to the method by which the government places contracts--either through the advertised or the negotiation method. Congress has expressed a preference for the formal advertised methodology based on the assumption that formal advertising engenders more competition. The goal is for the market to essentially determine the lowest price for a given item. For these procurements tight controls are exercised to insure that collusion does not occur. Sealed bids are received and controlled; at an announced time and place, the bids are opened. The sellers attend the opening and learn what prices were bid by their competitors. Contract award is made to the lowest responsive and responsible bidder, and the contract is awarded on a firm-fixed price basis.

Congress has identified seventeen exceptions to advertising and has stipulated that under circumstances, such as with educational institutions, or for foreign purchases and research and development, negotiation may be used as the placement methodology. For negotiation, a request for proposal or quotation process is used. Sellers that have products which meet the contemplated specifications are invited to submit proposals or quotations to satisfy the government's requirements. A diagram of the two methodologies is included in Figure 2.(9) A common misconception is that negotiation does not involve competition, however, as can be seen from Figure 2 this is not the case.

In general, the advertised methodology relates to the purely competitive market with firms from other market structures, such as monopolistic competition, and oligopoly bidding in those cases where a division or part of the firm produces a standard fairly homogeneous product which can be manufactured by many firms due to the general purpose nature of the product or service.

The pure competition structure relates to small business in the sense that the small business area has relatively free market entry and exit. Rosenberg states, "of 1,913,000 retail establishments in the United States in 1972 some 58 percent had fewer than four employees, and 53 percent did less than $100,000 in annual sales."(10) He further indicates that small business is a risky venture in that many of the firms barely survive from year to year and that the failure rate (exit from the market) is as much as 75 percent after five years or less. The replenishment rate is high since on an annual basis the number of small businesses continues to increase.



NOTES: [1]PLACEMENT METHODOLOGY IS GOVERNED BY US STATUTE.
[2]MULTIPLE SOURCES ARE NECESSARY FOR ADVERTISED PROCUREMENT.
[3]ADVERTISED PROCUREMENT MUST RESULT IN A FIRM FIXED PRICE CONTRACT.
[4]WEAPONS ACQUISITION DEVELOPMENT PROGRAMS GENERALLY FALL INTO THIS CATEGORY BY VIRTUE OF THE SOURCE SELECTION PROCESS.

Figure 2. The Procurement Process

As the market and product become more specialized, negotiation as a placement methodology is used. The United States is a high technology nation with defense needs which encompass the development of new and state-of-the-art weapon systems on a continuous basis. For sellers in this research and development area, therefore, it is to their advantage to develop a product or market to satisfy a government need which is so highly specialized that they are the only firm which can provide the item. These conditions where the government has the sole requirement and a seller the sole supply, leads to a large number of sole-source contracts. From an economic standpoint, the result is the bilateral monopoly market structure discussed earlier. The fundamental point is that of necessity there will be a proportion of purchases that may be competitively placed, yet a number that will be sole source in nature. The question is whether this proportion should be 38 percent competitive versus 62 percent sole source. Some enlightenment may be gained by examing the environment for contracting and acquisition.

THE COMPETITIVE ENVIROMENT

National security policy dictates that the nation remain militarily strong, and that the DOD obtain the requisite goods and services by contracting with the private sector. A strong defense requires the development and maintenance of high technology weapon systems. The process for developing and maintaining these defense systems is illustrated in Figure 3.(11) From a hardware perspective, the acquisition strategy chosen, such as concurrency, contract

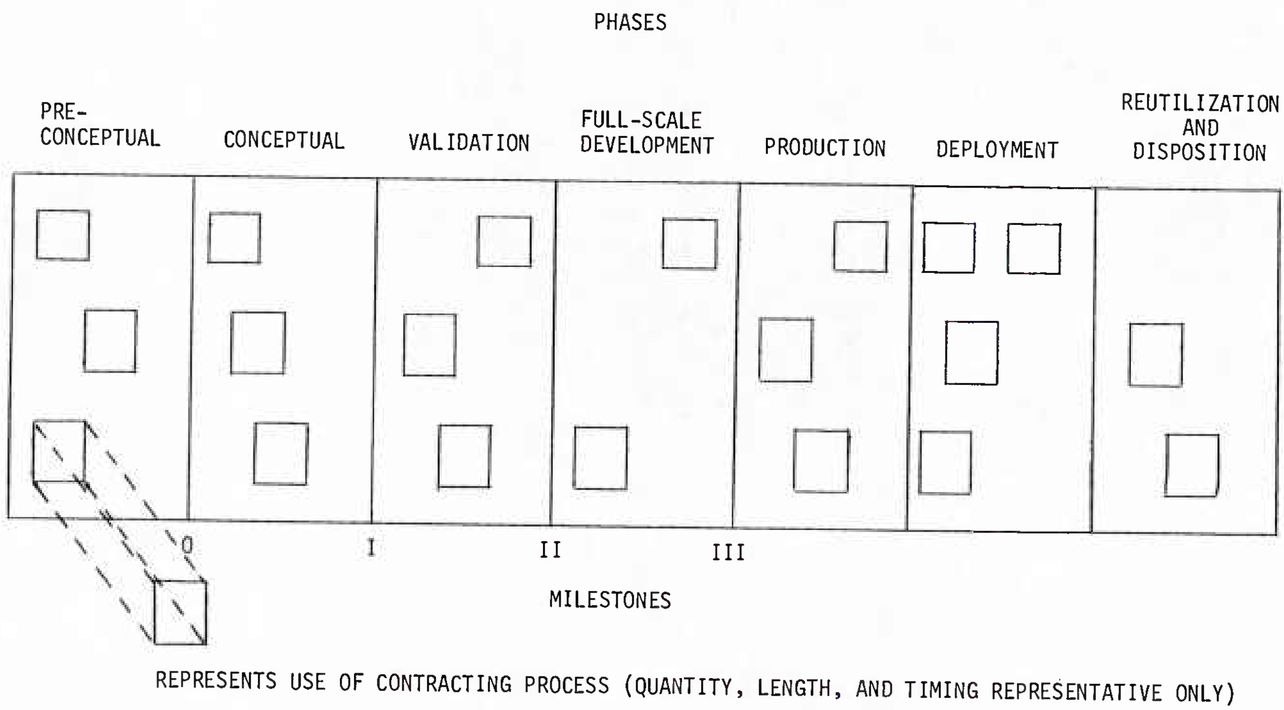
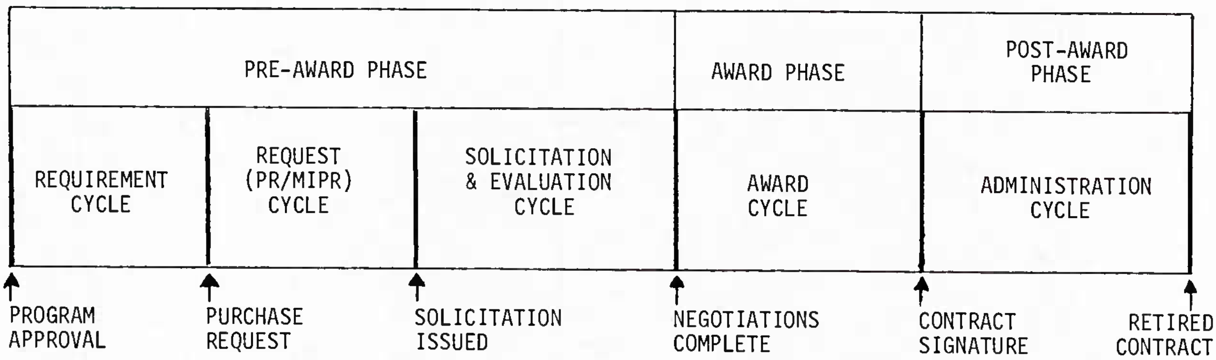


Figure 3. The Weapons Acquisition Process

defintion, prototyping, fly-before-buy, or other, will determine to some degree, how much competition will be a factor in terms of a given program. At each point in the weapons acquisition process represented by a square in Figure 3 where contracting is necessary, a decision has to be made as to placement methodology. The contracting process is illustrated in Figure 4.(12)



NOTE: RELATIVE LENGTH NOT SIGNIFICANT

Figure 4. Contracting Process

For a research program, in the preconceptual and conceptual phases of the acquisition process, it is difficult to obtain competition as the scientific advances are often made based on the unique skills and ideas of individual researchers or research groups. In validation where exploratory research is involved, there is more of a possibility that contract awards can be made competitively. As a matter of fact, the competition at this juncture can be quite intense. For example, the strategy for a given system may involve two or more contractors in a competitive fly-off to determine which firm will produce the production aircraft. The various types of procurements and the germane acquisition phase are related in Figure 5. Generally, as the weapon system moves through the weapons acquisition process and testing is completed and the item is deployed, it can be anticipated that specifications firm up and drawings become more standard thus permitting the use of the advertised methodology. This is shown in Figure 5 in the deployment column where base procurements for construction, supplies, and services (excluding small purchases under $10,000) are placed using the advertised methodology. In this phase spare parts for weapon systems are placed in the same manner. This discussion has placed competition in the perspective of its role and use in DOD acquisition. Several completed research studies which relate to various aspects of the subject, will be examined next.

Phase / Procurement	Pre-Conceptual	Conceptual	Validation	FSD	Prod	Deploy
Central:						
R&D	X	X				
Weapons		X	X	X	X	X
Spares				X	X	X
Base:						
Supplies						X
Services						X
Con-struction						X

Figure 5. Types of Procurement and the Weapons Acquisition Process

RESEARCH ANALYSIS

In terms of placement methodology and competition, an issue often raised is whether funds can be saved by switching from sole-source, negotiated buys to advertised competitive purchases. In 1963 the Southwestern Legal Foundation reported studies which disclosed that adequate specifications plus two or more qualified sources can result in reductions in price of about twenty-five percent on the average.(13) A 1972 US Army Electronics Command study concluded, "that introducing competition into a sole-source procurement would result in an expected acquisition cost savings of 40 percent to 50 percent."(14) This finding was supported by the Yuspeh study of 1973 which indicated, "that in 20 cases analyzed, there was an average price reduction of approximately 50 percent as a result of introducing competition into sole-source procurements.(15) In a 1974 study the effect of competition on the cost of aircraft replenishment spares was investigated. The study concluded, "that the net savings (loss) accompanying a shift from sole-source to competition is a function of gross savings (loss) in procurement dollars, procurement data costs, administrative costs, quality costs, and reliability costs."(16) Savings as a percentage ranged from 10.85 to 17.5. In a 1978 study by Lovett and Norton, sixteen items were analyzed where the acquisition methodology was switched from sole-source to competitive.(17) For five of the items no savings accrued, however, the other eleven accounted for average savings of 10.8 percent. In a later study, the Lovett and Norton model(18) was used to evaluate switching from sole-source to competitive and the savings were found to be at 19.6%.(19) Another Army Procurement Research office study showed similar results.(20) However, a study by Karst of the General Service Administration (GSA) policy of acquiring computer requirements by competition revealed that this methodology actually costs the government more than if the computer systems had been acquired by means of sole-source methodology.(21)

Obviously, the research consensus is that switching from a sole-source to the competitive methodology can save the government money. The key of course is the application of judgment as to which requirements should be competed. To accept a 25 percent or larger reduction as a necessary consequence of switching from one methodology to another as automatic is fallacious since administrative costs of going competitive and various other risks in that decision could mitigate the situation.(22)

Another area for competition in the DOD which has been investigated is the concept of

Leader-Follower. This situation where a basically monopolistic firm is required to essentially establish a second source for a given product is the duopoly market structure discussed earlier. A recent study removes the mystery from this concept and concludes "that for the experienced acquisition and contracting managers, leader/follower introduces no new or unusual challenges.(23) The cost savings objective in leader-follower is a function of the cost to establish the second source and the length of the ensuing production run. The production run must be long enough and produce a large enough quantity so that the savings involved are greater than the incremental cost. Lamm states that second sourcing can inject competition into the acquisition process but then very carefully enumerates several conditions for the use of the technique.(24) Necessary requirements include usable technical data, sufficient buy quantity, technical assistance personnel, interested sources, and sufficient lead time. Under certain circumstances then, dual sourcing can result in savings to the government by shifting from a sole-source to a competitive methodology.

A concern expressed by key policy makers in the past few years has been the impact of various government policies or acquisition techniques on the industrial base. A study by Christian and Riely had as its purpose to investigate the impact of the reliability improvement warranty (RIW) on interfirm competition in the avionics industry.(25) The research concluded that RIW had no impact on competition in the avionics industry for contracts with the DOD.(26) While this study revealed no degradation of the industrial base, the authors believe that this danger is ever present and should be monitored at all times. On the other hand, another view is that of Gansler who indicates that the tendency is away from the free market and at present there is excess capacity in the aircraft industry.(27) He advocates sectoral planning and the retention of only a select few firms to produce all the government aircraft. While an interesting concept, it does not seem to be substantiated by research nor by economic theory.

Others in their zeal to save the government money advocate streamlining the acquisition process to reduce the high cost of doing business with the government. The basic assumption is that these savings on the part of producers will be passed on to the buyers. Also there is supposed to be an accompanying in-house government savings which should permit the government to divert administrative dollars to alternate uses. Ostrowski points out that there are cases where tailored specifications are needed, however, in other cases they increase the cost to government.(28) His contention is that off-the-shelf items can in many cases be acquired competitively thereby saving the government funds. While not citing specific savings, he states that dollars can be saved and that procurement practices would be improved. The earlier discussion relative to the shift from sole-source to competitive buying seems to support his contention. Another study found that in a two-year test of the commercial buy philosophy that only about 50 percent of the procurements resulted in reduced costs.(29) Thus, this technique does not seem to be a panacea but can be used at times to reduce costs by injecting competition into the acquisition process. In addition to competing for products by firms as outlined above, savings have been claimed by using the computer to identify the low-cost supplier for a given product.(30)

Other ways to inject competition into the acquisition process include anti-trust action to change market structures, legislation to reduce merger activity and other regulatory actions.(31) However, these activities are not under the control nor in many cases the influence of the DOD. However, some approaches should be emphasized. One such concern is to control the specification development process to reduce "gold-plating." Also adherence to formal source-selection procedures which insure competition will aid this effort. Where cost effective, increased use of component breakout programs is advocated. In addition, the broadened use of two-step formal advertising in the research and development arena can assist in introducing competition earlier in the weapons acquisition process. Again studies have shown these techniques to have enhanced competition.(32) A final technique which has not been used but which has been advocated in the past is the use of an auction technique to award contracts.(33) This technique was originated by Col Gregory Frese, USAF, now retired. Welbaum and Freeman used the technique under controlled conditions to simulate contract award. They conclude, "the Auction Technique produced the lowest price and the smallest difference between the lowest bids and the second lowest bids,"(34) while the concept is not proven as a technique perhaps some DOD agency should be authorized to test the concept in an actual buy situation.

CONCLUSIONS

The term competition is not easily defined, but in the context of DOD acquisition it relates to the power of a firm within a given market structure and that firm's ability to control price. For the advertised methodology of purchasing goods and services, the market is supposed to deliver the items at the lowest price through the medium of competition. This situation occurs where the products involved are standard and homogeneous in nature. As the products become more specialized and complex, price must be negotiated between the two parties. For the weapons acquisition process, negotiation is more germane in the conceptual, validation, and full-scale development phases since the products are vaguely defined and non-standard. As a product is tested and then manufactured, the specifications and accompanying drawings become more standard and amenable to purchase by means of the competitive rather than the sole-source methodology.

Research supports these concepts. Studies show that where the product is amenable to competitive rather than sole-source methods of buying, dollars can be saved. Estimates of savings range from 10 to 50 percent. Another way to stimulate competition under certain conditions is by means of second sourcing and commercial buy practices. A provocative technique in theory is the "auction." To date, no actual auction has been used in DOD acquisition. Perhaps, the concept deserves a test. In the final analysis, competition does seem to be desirable in terms of reduced costs for goods and services which are consumed by the DOD, however, there does not appear to be any single technique that will insure competitive buys. Rather, research results imply that the basic mechanisms exist for the injection of competition into the acquisition process; the key seems to be a reliance on the competitive market and the application of judgment to the areas of acquisition planning and control to insure that the system works in the most beneficial way possible. A workable system of checks and balances will assist in providing this assurance to management and the American public.

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A PROCUREMENT STRATEGY FOR ACHIEVING EFFECTIVE COMPETITION WHILE PRESERVING AN INDUSTRIAL MOBILIZATION BASE

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ABSTRACT

When limited sources exist for producing critically needed equipment, the dichotomy of achieving effective competition so as to realize near term cost savings, while also maintaining multiple sources for future competition and industrial mobilization base considerations, is one which managers in the acquisition process must frequently deal with. Recently, a procurement technique was used which enabled the U.S. Army Electronics command to achieve meaningful competition while preserving the industrial mobilization base, which was limited to just two producers. In this technique, the percentage of the total procurement for award to each manufacturer is a variable, and is determined as a function of prices actually proposed.

INTRODUCTION

In the procurement of specialized or "state-of-the-art" systems, often there are a limited number of companies capable of meeting the government's requirements. In such cases, a conflict exists between the short-term financial considerations that favor obtaining the entire buy from the lowest-priced responsive and responsible offeror, and the long-term financial and industrial mobilization considerations that favor maintaining multiple sources. This conflict has traditionally been resolved by determining the quantity split between the prime and the alternate sources, e.g., 60 percent for the prime and 40 percent for the alternate, then negotiating two sole-source contracts. The underlying assumption here is that the prime source will bid the lowest price. This approach, while preserving the production base, fails to introduce comptition into the process, and therefore results in higher prices for the government.

A simplistic way to ensure that there is a degree of competition in the award is to announce that two sole-source awards will be made, with a pre-determined majority of the procurement quantity, e.g., 60 percent, going to the company submitting the lower-priced, responsive, and responsible offer. Although, theoretically, this technique does interject a degree of competition into the process, it is defective for the following reasons:

—A fixed-quantity split results regardless of whether the price differential is small or large.

—One or both of the companies could decide that the smaller quantity is sufficient, resulting in ineffective competition since they would feel no compulsion to be the low bidder.

—There is no incentive for a new company to approach the price it estimates a more experienced competitor will submit. A corollary to this is that an established manufacturer, knowing a competitor cannot beat his price, has no incentive to submit his best offeror.

During May through February 1978, a procurement approach was formulated and successfully implemented by the U.S. Army Electronics Command (ECOM) to achieve effective competition while preserving the industrial base which, at the time, was limited to only two qualified producers. In this approach, the quantity split was determined as a mathematical function of the difference in prices actually proposed. The mathematical function was designed to create a balance between minimum near-term procurement costs and effective industrial mobilization.

THE PROCUREMENT APPROACH

At the time of this particular procurement cycle, only two companies were qualified to produce a sophisticated night vision system. One company had been the development contractor and, up until the time of this solicitation, had production contracts totaling about 6,900 units. The second company was the alternate source established to provide competition and an industrial mobilization base. Before the issuance of this solicitation, the second company had production contracts for about 2,900 units.

When this solicitation was issued, the monthly production rates at the first and second sources were approximately 230 and 40, respectively.

Under the provisions of the production plan, a sole-source contract was to be awarded to each of the two qualified producers for a total of 10,284 systems and 3,608 spare critical components.[1] The production plan stated that the quantities to be awarded each company would be based on competitive-range bids. Furthermore, the secretarial determination and findings (D&F), which authorized procurement by negotiation, stated that "such division will be made by evaluation of competitive-range bids and determined based on price and/or other factors considered to be in the best interest of the government." Because each contract was for 2-year multiyear awards, a sole-source ASPR deviation was obtained under 3-216.

RELATING PRICE DIFFERENCE TO QUANTITY SPLIT

Before the solicitation was issued, a mathematical equation was devised that could be used to determine the proper split of the procurement quantities between the two companies based on the difference between their proposed prices. This equation represented management's assessment of an equitable balance between the short-range goal of procuring the current quantity at the lowest possible price, and the long-range goal of maintaining a competitive industrial base.

The equation used to determine the quantity split as a function of the difference in proposed prices was as follows:

$$\text{\% of procurement quantity for Company A} = f(x) = \left[\frac{x}{|x|}\left(\frac{\text{arc tan }(75x^2)}{90}\right)+1\right]50\%$$

$$\text{Where } x = \frac{\text{Company B Price - Company A price}}{\text{Company B price + Company A price}}$$

This equation is represented graphically in Figure 1.

The symbol x was chosen as the difference in proposed prices divided by the sum of the proposed prices. This was done to reflect the fact that the significance of a given price difference is actually dependent on an item's price. For example, the difference between two prices for an item of $1,000 and $2,000 is more significant than a difference on some other item of $10,000 and $11,000, even though in both cases the actual difference is the same. Also, by dividing by the sum of the prices, the equation becomes independent of who is called Company A and who is called Company B.

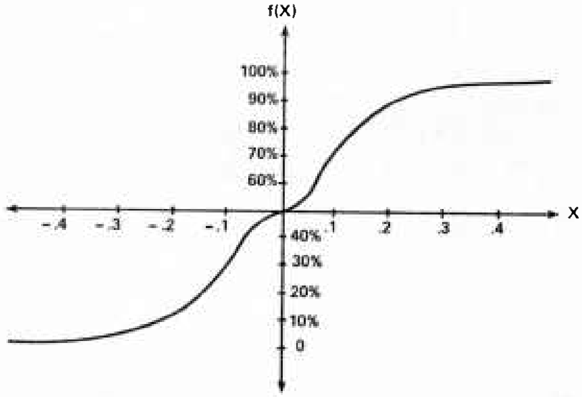

Figure 1. Equation Used in ECOM Procurement

Partly because it was considered desirable for both companies to be producing at comparable rates and partly because of the difference in experience between the two companies, it was decided that the split should be a mild one if the prices were close. The curve is therefore relatively flat in the 50-percent split range.

It was determined that in order to be a viable producer and thus become an active part of the industrial mobilization base, a company would need to receive at least 10 percent of the award. It was felt that jeopardizing the industrial base by awarding less than 10 percent to a company could only be justified if the price difference was great. With the equation used in this case, a 90 percent–10 percent split occurs when one company's price is 50 percent higher than the other's.

In determining a quantity split as a function of a price difference, it is important that the functional relationship used accurately reflect management's acquisition concepts.

The equation presented is of the general form:

$$f(X) = \left[\frac{AX}{|X|} \left(\frac{\text{arc tan } B|X|^{C}}{90} \right) + 1 \right] 50\%$$

By changing the constants, A, B, C, this general equation can be modified to meet a wide range of management concepts. This is shown in Figures 2, 3, and 4.

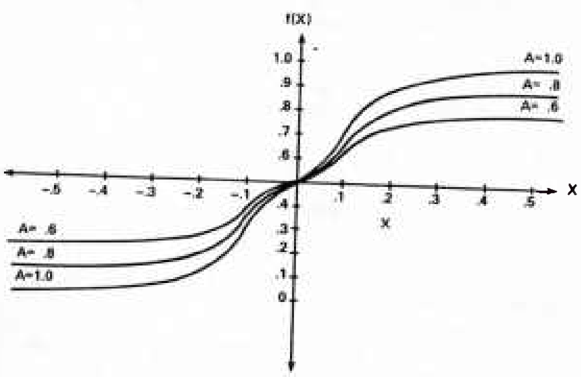

Figure 2. Effect of Changing A While Keeping B=75 and C=2

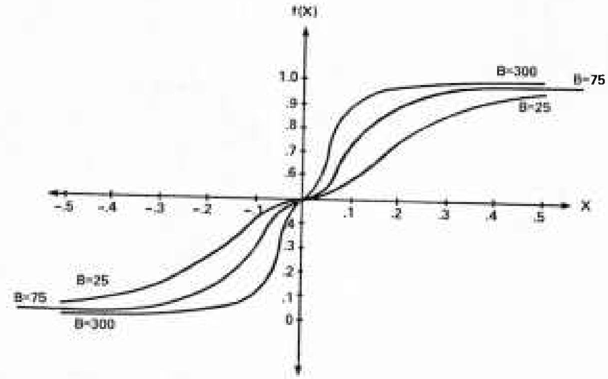

Figure 3. Effect of Changing B While Keeping A=1 and C=2

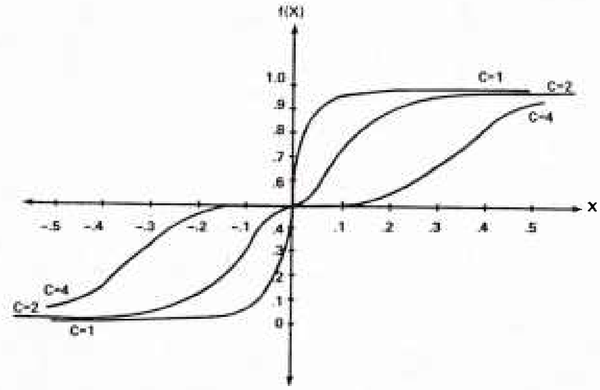

Figure 4. Effect of Changing C While Keeping A=1 and B=75

In tailoring the general equation to a specific procurement, all three constants (A, B, and C) should be varied in combination to achieve the desired relationship between the price difference and the quantity split.

This general equation can accommodate a large number of situations, but there are circumstances when one might find that it cannot be adapted to the needs of a specific procurement. In such cases one can develop any other relationship that will relate the price difference to the quantity split. While it is desirable that the relationship between price difference and quantity be plotted as a continuous function, this is not essential. Step functions, ramp functions, and tables are some other ways of expressing the relationship. The important thing is that before issuing the solicitation, an explicit relationship be written to relate the difference in proposed prices to a split of the total procurement quantity.

Although the procurement strategy presented in this paper deals with splitting a procurement quantity between two producers, the concept is easily expandable to splits among three or more producers. This is shown in Appendix A.

THE SOLICITATION

In the case of the ECOM Procurement, both Section D of the solicitation (RFP) and an executive summary that accompanied the solicitation explained how the quantity to be awarded each contractor would be determined. The solicitation was very specific in this regard, and even contained a detailed illustrative example; it did not disclose the equation to be used. The equation was withheld because it was felt

that the contractors should submit their best price, in competition with each other, rather than trying to jockey for position on a mathematical curve.

The solicitation instructed the prospective contractors to submit prices for seven quantity ranges. These ranges, which ran from 2–2,000 units at the low end to 12,002–14,000 units at the high end,[2] encompassed all possible splits of the total Army procurement, plus additional requirements that might have been generated by other government agencies or foreign military sales (FMS).

It was stated in the solicitation that, for purposes of determining the quantity split, the price proposed for the range encompassing one-half the total procurement quantity would be used. The solicitation also instructed each manufacturer to indicate the dollar amount of government-furnished equipment (GFE) to be used on a resultant contract; also that this amount, along with the dollar amount for separately priced software, would be applied on an amortized basis to the proposed hardware prices. Additionally, it was stated that if an offeror's price was greater for a quantity range larger than that used in the split determination, the government had the right to award a quantity within the evaluated range. (The entire executive summary and the applicable portions from Section D of the solicitation are reproduced in Appendix B.)

SEQUENCE OF EVENTS

Upon receipt of the proposals, the pricing portions were extracted and locked in a safe. The technical portions of the solicitation were evaluated, and technical discussions with each offeror were conducted. After the discussions, each offeror was informed of agreements reached between the government and the other company, and told that the government was willing to have similar agreements with him concerning terms, conditions, and technical requirements. At the completion of this process, each company was requested to submit updated pricing information. The pricing proposals were then opened and found to be adequate. No additional requirements materialized from other government agencies or from foreign military sales, so the total procurement quantity remained equal to the Army's requirement of 10,284 units. The range that encompassed one-half the total procurement quantity was, therefore, range C 4,002–6,000 units. The prices quoted by each company for range C, after adjustment to reflect GFE and software costs, were put into the mathematical equation; the quantities to be awarded each contractor were determined; and the contractors were notified.

From this point on, the procurement process followed conventional procedures leading to two sole-source awards. Proposed labor hours, material usage, and yield rates were evaluated by the cognizant technical personnel, and audits were performed. Procurement pricing personnel reviewed the information provided and made inputs to the contracting officer. In the case of the company with the lower offer, his price was found to be fair and reasonable, and further negotiation was unwarranted. With regard to the higher-priced offeror, price negotiations were entered into and, after a modest price decrease, agreement was reached. Two fixed-price, sole-source contracts were subsequently awarded.

RESULTS

The two contract awards totaled nearly $74 million. This represents a savings of approximately $7 million from budget estimates, and is attributable to the introduction of competition. Perhaps what is even more significant is that it was the "alternate source" who submitted the lower price and thus captured the majority of the procurement. Had a conventional procurement strategy been used in awarding the two sole-source contracts, the major quantity would have been designated for the more established producer who had been the low bidder in the past, and who was projected to be the low bidder on this procurement. Thus, the use of this innovative procurement strategy resulted in a government savings of approximately $7 million; the introduction of effective competition into the procurement; and the continuation of an established mobilization base.

It should also be noted that, as a result of the competitive element in this procurement approach, the time required for price negotiation, particularly with the low offeror, can be reduced, thus shortening the entire procurement cycle.

CONCLUSION

The simple technique of splitting a procurement quantity between two or more producers based on a fixed ratio (e.g., 60 percent vs. 40 percent), is often ineffective and inequitable; however, by developing a functional relationship between the proposed prices and the split of the total procurement quantity, effective competition can be introduced in a controlled manner. Management can then strike an optimal balance between the benefits to be derived from competition, and the benefits to be derived from an industrial mobilization base.

ACKNOWLEDGMENTS

I would like to acknowledge the dedicated efforts of Major Carl Messenger, who was the contracting officer for the procurement cited in this paper. I also want to acknowledge contributions made by people of the U.S. Army Electronics Command's Night Vision Laboratory, Procurement Directorate, legal office, and command group, whose support and comments made this procurement strategy both possible and successful.

FOOTNOTES

1. For simplicity, this paper will not specifically address the split of the 3,608 spares, which was handled as a parallel action identical with the splitting of the 10,284 systems.

2. Because the contracts were to be 2-year, multiyear awards, it was necessary to request separate range bids for each year. Thus, the actual solicitation has ranges from 1 to 1,000 units to 6,001 to 7,000 units, for the first year, and identical ranges for the second year. The ranges were then combined to give the effective ranges indicated above.

APPENDIX A

While the procurement strategy as presented in this paper has dealt with the splitting of a procurement quantity between two producers, the concept is easily expandable to splits among three (or more) producers. To do this, one determines the split between Companies A and B as a function of their proposed prices and then determines the split between Companies B and C as a function of their proposed prices. (The equation used to determine the split between Companies A and B need not be the same as that used to determine the split between Companies B and C). Three equations are then established; one relating the percentage for Company A to the percentage for Company B, one relating the percentage for Company B to the percentage for Company C and one reflecting that Companies A, B and C combined receive the entire procurement quantity. These three equations can then be solved simultaneously to find the percentage of the total procurement quantity which each Company receives. This can be expressed mathematically as follows:

Let p = portion determined for Company A relative to the total for Companies A and B combined.

Let p' = portion determined for Company B relative to the total for Companies B and C combined.

Then:

$$\frac{\text{portion for Co. A}}{\text{portion for Co. A} + \text{portion for Co. B}} = p$$

$$\frac{\text{portion for Co. B}}{\text{portion for Co. B} + \text{portion for Co. C}} = p'$$

$$\text{portion for Co. A} + \text{portion for Co. B} + \text{portion for Co. C} = 1$$

Solving these three equations simultaneously yields:

$$\text{portion for Co. A} = \frac{pp'}{1 - p + pp'}$$

$$\text{portion for Co. B} = \frac{p' - pp'}{1 - p + pp'}$$

$$\text{portion for Co. C} = \frac{1 - p - p' + pp'}{1 - p + pp'}$$

If there were more than 3 Companies, say n Companies, among which the total procurement quantity was to be divided you could form n equations with n unknown quantities which could be solved to give the portion of the total procurement to be awarded to each of the n Companies.

SOLICITATION NO. DAAB07-77-R-3290 /0001

EXECUTIVE SUMMARY

This solicitation is issued pursuant to the authority of ASPR 3-216 to maintain the production base of the critically needed night vision items included herein. Consistent with this objective, the Government plans to make two (2) awards; the maximum quantity awarded not to exceed 90 percent and the minimum quantity awarded not to be less than 10 percent of the total quantity stated in this solicitation.*

Through these contracts, the Government intends to procure approximately 10,284 Night Vision Goggles, AN/PVS-5A, approximately 3,608 spare Image Intensifier Assembly, 18MM Microchannel Wafer MX-9916/UV, related software, and requirements for foreign military sales and other governmental agencies which might occur prior to date of award.

In lieu of the Government determining prior to solicitation the quantity to be awarded each producer, it has been determined to be in the best interest of the Government and consistent with the objective of this procurement to solicit currently qualified producers and then, determine in accordance with the evaluation criteria of SECTION D the quantity to be awarded each offeror as a result of their basic proposals submitted in response to this solicitation. The offerors by reason of their proposals will influence the quantities to be awarded each offeror. Proposed prices submitted in the basic proposal will be evaluated at the range which represents one half of the total quantity of each item, i.e., range C[1] for the Goggles and range B[1] for the Image Intensifier Assemblies. The quantities of the Goggles and Image Intensifier Assemblies to be split between each offeror will be a function of the price differential between offered prices, with the low responsive, responsible offeror for each of the equipments receiving the majority of the respective equipments. An illustration of this procedure is contained in SECTION D for information purposes. Subsequently, it is planned to negotiate with each offeror for the determined quantity using the price proposed for such quantity as the basis for negotiation and subsequent award. It is therefore very important that each proposal be responsive to the solicitation provisions and be submitted on the most favorable terms including price which the offeror can submit to the Government.

Author's Footnote (not part of Solicitation)

* This reflects a command group decision to preclude even a remote possibility of a split more severe than 90-10 occurring. As shown in
also be achieved during the formulation of the equation relating the prices proposed with the quantity split.

Solicitation No. DAAB07-77-R-3290 Contract No._____________

PART I - SECTION D - Evaluation Factors for Award Page of

D.51 Basis for Award.

1. The contract will be awarded to that responsible offeror whose offer conforming to the solicitation will be most advantageous to the Government, price and other factors considered. The Government plans to make two awards.

2. The price of Goggles (AN/PVS-5A) proposed under CLIN 0001 shall be the same as those proposed under CLIN 0017 for like ranges. Similarly, the price of spare Image Intensifier Assembly, 18MM Microchannel Wafer MX-9916/UV propsed under CLIN 0009 shall be the same as those proposed under CLIN 0025 for like ranges.

3. The quantity of Goggles to be awarded each responsive, responsible offeror will be determined as follows:

a. The Goggle quantity ranges for each year of the multi-year award will be combined to produce a Goggle multi-year range with corresponding prices.

b. For the quantity range encompassing one-half of the number of Goggles to be awarded, the price difference between proposals will be analyzed.

(1) The price used in the analysis will be that proposed for the relevant Goggle range plus pertinent software prices and the rent-free use evaluation factor referred to in Subsection D.25, amortized over the mid-range quantity plus all other evaluation factors referred to in Section D, for example, discounts.

c. The percentage split between offerors shall be determined as a function of the price split with the low offeror receiving the majority of the Goggle award. Goggle quantities to be subsequently negotiated with each offeror will then be announced.

d. The price proposed by each offeror, for the Goggle quantity range encompassing the quantity determined for him, will be the basis of negotiation.

e. In the event a proposal indicates a higher price for Goggles in a greater quantity range than that at which the price is analyzed, the Government reserves the right to split the award such that each offeror receives a quantity within the range analyzed.

4. The quantity of tubes to be awarded each contractor will be determined per paragraph 3 with the word "tube(s)" substituted for "Goggle(s)," using the identical evaluation procedure.

Solicitation No. DAAB07-77-R-3290 Contract No.________________
PART I - SECTION D-Evaluation Factors for Award Page of
D.51 (Cont'd)

The following example is included to further clarify the evaluation and contract award procedure.

Two offers are received from qualified producers. The proposals are reviewed and it is found that neither proposal is non-responsive to the solicitation. The range bids are then reviewed and the following is found:

CLIN 0001 - Goggles

				Co. A Hdw Price	Co. B Hdw Price
A	1	-	1000	$10,000	$11,000
B	1001	-	2000	9,000	10,000
C	2001	-	3000	8,000	9,000
D	3001	-	4000	7,000	8,000
E	4001	-	5000	6,000	7,000
F	5001	-	6000	5,000	6,000
G	6001	-	7000	4,000	5,000

CLIN 0017 - Goggles

				Go. A Hdw Price	Co. B Hdw Price
A	1	-	1000	$10,000	$11,000
B	1001	-	2000	9,000	10,000
C	2001	-	3000	8,000	9,000
D	3001	-	4000	7,000	8,000
E	4001	-	5000	6,000	7,000
F	5001	-	6000	5,000	6,000
G	6001	-	7000	4,000	5,000

Solicitation No. DAAB07-77-R-3290 Contract No.____________
PART I - SECTION D - Evaluation Factors for Award Page of

D.51 (Cont'd)

Software costs are found to be as follows:

FOR PURPOSES OF THIS EXAMPLE, RENT-FREE USE CHARGE AND DISCOUNTS ARE NOT APPLICABLE.

Co. A. -	CLINS 0002 thru 0007 less SLINS 0003AB and 0003AC =	$ 6,000
	CLINS 0018 thru 0023 less SLINS 0019AB and 0019AC =	4,000
	Total of pertinent software price =	$10,000
Co. B.	CLINS 0002 thru 0007 less SLINS 0003AB and 0003AC =	$ 8,000
	CLINS 0018 thru 0023 less SLINS 0019AB and 0019AC =	7,000
	Total of pertinent software price	$15,000

Combining the single year offers and adding in amortization of pertinent software costs results in the following table:

(TABLE ON NEXT PAGE)

Solicitation No. DAAB07-77-R-3290 Contract No. ______________________
PART I - SECTION D - Evaluation Factors for Award Page of

D.51 (Cont'd)

Multi-Year Goggle Range	Co. A. Hardware Price + Amortized Software = Analysis Price	Co. B Hdw Price + Amortized Software = Analysis Price
A[1] 2 - 2000	\$10,000 + 10,000/1000 = \$10,010	\$11,000 + 15,000/1000 = \$11,015
B[1] 2002 - 4000	9,000 + 10,000/3,000 = 9,003	10,000 + 15,000/3,000 = 10,005
C[1] 4002 - 6000	8,000 + 10,000/5000 = 8,002	9,000 + 15,000/5,000 = 9,003
D[1] 6002 - 8000	7,000 + 10,000/7000 = 7,001	8,000 + 15,000/7,000 = 8,002
E[1] 8002 - 10,000	6,000 + 10,000/9000 = 6,001	7,000 + 15,000/9,000 = 7,002
F[1] 10,002 - 12,000	5,000 + 10,000/11,000 = 5,001	6,000 + 15,000/11,000 = 6,001
G[1] 12,002 - 14,000	4,000 + 10,000/13,000 = 4,001	5,000 + 15,000/13,000 = 5,001

D.51 (Cont'd)

As the award of approximately 10,284 Goggles is contemplated, the percentage split will be determined as a function of the price difference between the two companies for the 4,000 - 6,000 multi-year Goggle range, as this is the range encompassing 50 percent of the anticipated award.

The percentage of the quantity for Company A is then found as a function of the price difference between $8,002 and $9,003. For the purpose of this example, it will be assumed that this function is such that the percentage for Co. A is 60 percent. Co. B. will then receive 40 percent. The quantity split of the 10,284 Goggles will thus be:

60 percent of 10,284 Goggles = 6170 Goggles for Co. A.
40 percent of 10,284 Goggles = 4114 Goggles for Co. B.

A similar procedure will be performed with the tube range bids. For purposes of this example, assume such procedure indicates award of 2,008 tubes to Co. A at $2,000 and 1,600 tubes to Co. B at $2,700.

Negotiations will then commence with Co. A for the purpose of procuring 6,170 Goggles and 2,008 spare tubes with a Goggle price of $7,001 and a tube price of $2,000 as the basis of negotiation.

During the same time frame negotiations will also commence with Co. B for the purposes of procuring 4,114 Goggles and 1600 tubes with a Goggle price of $9,003 and a tube price of $2,700 as the basis of negotiation.

The figures used in this example are provided for illustration purposes only and are not meant to be indicative of actual or anticipated proposal prices, contract quantities, or the precise relationships between price difference and quantity split.

PREDICTING THE COSTS AND BENEFITS OF COMPETITIVE PRODUCTION SOURCES

J. W. Drinnon

J. S. Gansler

THE ANALYTIC SCIENCES CORPORATION

FOREWORD

This paper presents the results of an acquisition study undertaken by TASC for the Joint Cruise Missiles Project Office. The purpose of the study was to develop a methodology for predicting the net savings in production costs due to competitive, dual source production of the cruise missile, as opposed to sole-source production. This paper details the theoretical concepts underlying the methodology, describes the methodology, discusses the data base which was used for estimating the parameters in the model, and presents illustrative results.

1. INTRODUCTION

Numerous studies have attempted to estimate the impact of competition on weapon system acquisitions. The sophistication of the studies has increased markedly over time. However, several difficult problems remain. First, an adequate data base has not been assembled and the existing data are in many ways incomplete. Data on learning rates (i.e., how unit cost varies with quantity produced) are often missing, as are discussions of the uncertainty in the estimates presented. The sources and reliability of data also are difficult to establish.

A second problem is the lack of a common framework which would allow comparisons of various findings. Partly this is a result of the previous studies having omitted important factors and partly it reflects the numerous methods used to evaluate the impact of competition in past programs. By placing numerous prior studies into a common framework, the authors have greatly reduced the apparent dispersion in results.

Third, the prior studies attempted to quantify the impact of competition in past acquisitions, rather than develop a <u>predictive</u> framework which could be used in future programs.

Fourth, the concept of competition is not set out clearly in the previous studies. Competition may describe a <u>force</u> which drives firms to reduce costs and profits and become more efficient, or competition merely may refer to the <u>number of firms</u> involved in an acquisition. Two or more firms contending for a government contract comprise a competitive situation; one firm does not. Similarly, multiple sourcing may involve either direct competition or multiple sole-source awards. Further, acquisition strategies involving competitive source selection procedures may result in one or multiple awards. Thus, it is important to define competition carefully, which many studies fail to do.

Given the problems in the existing studies, the authors set out the following approach:

- Assemble data from previous studies on costs and benefits of competitive production sources
- Construct a common baseline to compare results of those studies
- Develop a computer-based analytic model for cost/ benefit and sensitivity analyses
- Obtain new data as required
- Estimate uncertainty ranges for previous results and for new data
- Estimate likely net costs or net savings (under various assumptions) due to competition during an example cruise missile production program.

Section 2 of this report describes the development of a common baseline and a theoretical framework for the analysis of competition. Section 3 reviews the results of previous studies, the problems with the studies, and how the results tie into the TASC approach. Section 4 combines the theoretical framework and the empirical results (both the previous results and TASC's data) to develop a preliminary acquisition model. Limited results, under assumptions appropriate to an example missile production program, are obtained. Section 5 summarizes and concludes the report.

2. COMPETITION IN ACQUISITION

Costs and Benefits of Competition. Studies of competition typically begin with a discussion of learning curves. The learning curve is the relationship between the unit cost (or unit price) of an item and the quantity of the item produced. A "90 percent" learning curve is one in which a doubling of output drives cost down to 90 percent of its initial value. That is, a doubling of output leads to a 10 percent unit cost reduction. Similarly, for an 80 percent learning curve, a doubling of output causes a 20 percent reduction in unit cost.

For a particular learning curve, the greater the output, the lower is the unit (and total) production cost. Thus, the cost of the one hundredth item produced by a firm will be 20 percent lower than the cost of the fiftieth, if the firm has an 80 percent learning curve. This leads to one of the key questions regarding competition: is it less costly to have one firm produce all one hundred items on a sole-source basis in order to drive down unit cost, or should, say, two competing firms divide the run? If each firm in the above example produces 50 units, learning curve theory states that the sum of the two firms' total costs will be 20 percent higher than would have been the costs for one firm producing all one hundred units. However, it is likely that the force of competition will drive down the costs and profits of the competing firms and may improve their learning curves to, for example, 75 percent, rather than the 80 percent which obtained in the sole-source situation. Figure 2.1-1 illustrates the example above. The total cost of two production sources would equal twice the shaded area in the figure, while the cost of one firm would equal the entire area under the curve, up to the one hundredth unit. Twice the shaded area clearly is larger than once the entire area, if there is no reduction in costs and no change in the slope of the learning curve.

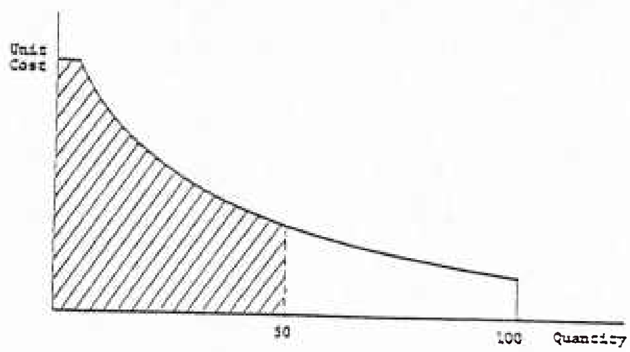

Figure 2.1-1 The Effect Of Splitting Production Runs

The above "cost" of competition is referred to as a learning cost: the unit costs for a multiple source production run will not be driven down to the level they otherwise would have been under a sole-source production run, since each firm has a smaller production run.

Other costs resulting from competitive production sources include initial technology transfer costs and the one time start-up costs of additional facilities, jigs, fixtures, and tools. Also, there may be technology transfer costs which continue throughout the production run, such as royalties and fees paid by one firm to another. Finally, there may be increased operation and support costs resulting from multiple production sources.

On the other hand, competitive production sources may result in lower costs, lower profits, and improved learning curves. In addition, firms may be more technologically progressive in developing cost-reducing design changes and improvements in manufacturing technology in order to gain an advantage over, or to offset breakthroughs by, their competitors. Such progressiveness could have long term positive effects on U.S. industrial productivity, in addition to reducing costs on the current production run.

There are other potential benefits of competition. For example, wider dispersion of production among firms will reduce the likelihood of supply failures resulting from strikes or national disasters. Similarly, the likelihood of meeting delivery schedules may be increased, a contractor's incentive to propose cost-increasing changes may be decreased, and equipment quality may improve under competitive conditions. Further, a greater distribution of work may strengthen the defense peacetime industrial base, increase surge capacity, and improve the nation's capacity for mobilization. Finally, the existence of competitive production sources for a weapon system provides the government with the opportunity subsequently to evolve under competitive conditions advanced versions of the system.

In order to quantify the likely costs and benefits of competition, it is necessary to obtain reliable data on the above factors and to create a framework which combines their respective impacts. Uncertainty of estimates also must be considered, along with the sensitivity of the results to changes in particular factors. Section 3 addresses the data problem, while the remainder of this section discusses the analytical framework developed by the authors.

<u>Framework for Analysis</u>. In order to consider the simultaneous effect of several of the factors described above, it is necessary to transform the standard learning curve (Figure 2.1-1) into its logarithmic form. This transformation produces a straight line learning relationship as opposed to the form in Figure 2.1-1. Figure 2.2-1 illustrates this form.

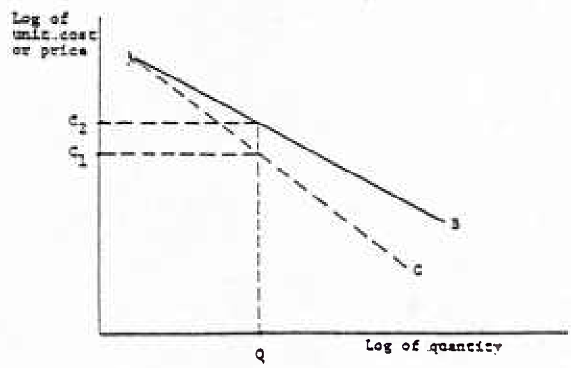

Figure 2.2-1 The Learning Effect Displayed in Logarithmic Form

The steeper the learning curve's slope, the greater are the cost reductions which can be obtained from increased quantity. Curve AC predicts a cost of C_1 at quantity Q, while curve AB predicts the higer cost C_2 at Q. The starting point of the

two curves is the same (point A); only the slopes (i.e., the rate of learning) are different.

The learning costs of competition may be represented exactly as in Figure 2.1-1. However, the benefits of competition can be more clearly represented using the transformed learning curve rather than the nonlinear expression displayed in Figure 2.1-1. Figure 2.2-2 illustrates three of the basic benefits.

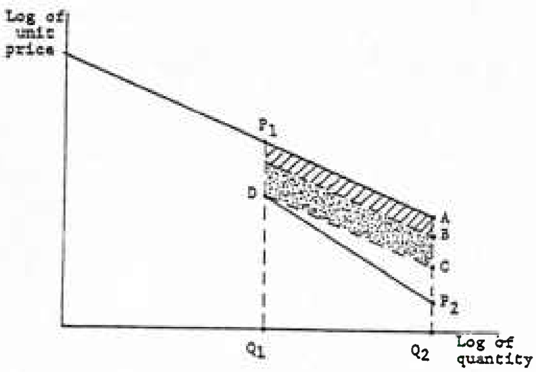

Figure 2.2-2 Learning Curve Effects of Competition

In Figure 2.2-2, it is assumed that production was sole-source up to Q_1 units. At that point, a second source was established, with a competitive contract awarded for the remaining Q_2-Q_1 units. It is assumed that the original firm won the competition (or won part of a split buy). That firm's final sole-source unit price P_1 fell to P_2 at the end of the competitively awarded production run. Clearly, the total difference P_1-P_2 cannot be attributed to competition, since the firm's price would have fallen to point A regardless of competition (i.e., the firm would have progressed along its learning curve regardless of competitive pressures). Thus, the distance AP_2 is the savings from competition. (This is not the <u>net</u> savings, since learning cost penalties from splitting the award, as well as other costs and benefits, are not considered. It also is not the <u>total</u> cost savings since it applies only to the last unit.)

The price reduction AP_2 can be divided into three parts: AB, BC, and CP_2. The curve's parallel downward shift from A to B results from the <u>reduction in profit</u>; the area just above the dotted B line represents the total savings resulting from the firm's reduced profit. The reduction from B to C represents the <u>cost reduction</u> which the firm effected. It also is a parallel shift downward, with the area between B and C representing the total savings obtained by such cost reductions. The final reduction from C to P_2 represents a reduction based upon the firm's developing, under competition, a <u>steeper learning curve</u> (i.e., a faster rate of learning). The line DP_2 reflects the steeper slope and the area in triangle DCP_2 equals the total savings as a result of increased learning.

The total area in $P_1AQ_2Q_1$ represents what the total costs would have been if the government would have remained with a sole-source producer. The area $DP_2Q_2Q_1$ represents the actual costs obtained under competition. The area $DP_2Q_2Q_1$ divided by the area $P_1AQ_2Q_1$ is the proportion of costs saved due to competition.

It is important to recognize the cost reduction resulting from improved learning -- area DCP_2. If such learning changes are ignored, the entire change AP_2 is likely to be attributed to all future buys. However, it is clear from Figure 2.2-2 that the size of CP_2 critically depends upon the total number of units produced. If the combined profit and cost savings can be established at, say, 15%, that saving rate can be applied to all future units

produced. However, the gains from the downward rotation of the learning curve (about point D) increase as the number of units produced increases.

The fact that the learning gains are dependent upon the number of units produced makes interpretation of previous studies somewhat difficult. For example, if the competition savings from some program were determined to be ten percent, it would be inappropriate to apply that percentage savings to a forecast of costs in any other program, since the savings depended upon the size of the run. A larger run would have produced greater benefits and a smaller run smaller benefits.

3. DATA BASE ON COMPETITION

Numerous studies on the costs and benefits of competition in production have been published. The results of the studies show a large range of estimates of net savings due to competition varying from over fifty percent to a negative ten percent and lower. However, part of this wide dispersion of results can be accounted for (and corrected) by analyzing the way in which the savings were calculated.

Typically, the studies estimated cost reductions resulting from competitive reprocurements of previous sole-source contracts. To obtain the percent savings due to competition, they divided the total dollar savings by the entire program costs. However, since the savings were obtained only during the competitive phase, it is more appropriate to divide the savings by the costs experienced during only that phase -- the "to go," competitive period of production. Within the last year, a major study has adopted this approach, but earlier studies had to be adjusted.

A second factor leading to dispersion of the results is the omission by various studies of different key variables. For example, some studies did not project sole-source "would have been" costs using a learning curve, but simply took the last sole-source price as the baseline for comparison with prices obtained during competition (i.e., they based their calculations on P_1 instead of A, in Figure 2.2-2). This calculation overestimated the savings due to competition. Further, different analyses were not careful in distinguishing between cost and price (which overlooks the profit impact [A to B in Figure 2.2-2] of competition). In no case was the change in slope of the learning curve used in the analysis, even though that phenomenon has long been recognized as a relevant factor.

A third type of omission is the lack of attention given to the uncertainty of estimates. Consideration of such uncertainty requires analysis of the dispersion of data points and an ability to undertake sensitivity analyses to determine the crucial factors. Few studies addressed either the uncertainty or the sensitivity problem.

The authors recomputed the savings -- to the extent data were available -- according to the "to go" approach. Further, since start-up costs were only occasionally included and always ill-defined in previous studies, they were always excluded in TASC's recomputation of savings reported in the past studies. Data dispersion was computed. Again, to the extent possible, learning curves were incorporated into the estimation of savings. The final result of this analysis of the previous studies -- along with original data collected by the authors -- was that the enormous dispersion of results across those studies was greatly reduced. Further, when the results for specific groups were computed (aircraft, missiles, electronics, etc.), the dispersion was even smaller. Thus, it is possible to say with reasonable confidence what the savings due to competition have been in various types of programs.

If it is possible to estimate the cost savings achieved as the result of competition in particular programs in the past, is it then possible to extend those results to even virtually identical programs to predict future savings from competition? The answer is: not necessarily. Even if the product, the firms, and external circumstances were identical in the former and the current programs, such an extrapolation could be drastically wrong. This point was made in the discussion of Figure 2.2-2. Factors which shift the learning curve downward (cost and profit reductions) can be applied as a constant percentage to all units competitively produced. However, the savings resulting from the change in learning curve slope actually increase in percentage as the number of units increases. Thus, a twenty percentage point reduction (5% due to decreased profit, 10% due to decreased cost, 5% due to increased learning) in one program's costs could translate into a thirty percentage point reduction in an identical program, due solely to the greater number of units produced in the second instance (5% due to decreased profit, 10% due to decreased cost, 15% due to increased learning).

The point of the above analysis is this: after the data have been analyzed, a reasonable estimate of the impact of competition in a particular program or group of programs may be made. However, because part of the savings are directly dependent upon the number of units produced, those estimates cannot be used immediately as predictors for other programs. Instead, it is necessary to divide up the total savings into its components: reduced profit, reduced cost, and increased learning. The first two can be applied immediately, but the third requires information on how many units are to be produced. The model and the analysis in Section 4 follow such an approach, using the refined data from the earlier studies.

4. ACQUISITION MODEL AND ANALYSIS

Overview of Model. The mathematical basis of the model, using elementary calculus and matrix algebra, is omitted from this paper, because of space constraints. Figure 2.2-2 provides the geometrical basis of the model. Computer software has been developed which calculates the total cost of production for sole-source and multiple-source awards. The model takes account of the three types of price reduction described above, as well as the various costs of competition (increased start-up and technology transfer costs, increased operation and support costs, reduced learning benefits). Results can be obtained for any number of units produced over any time period and for any inflation and discount rates. In addition, learning rates and the proportion of the total buy awarded to each firm may be varied. The dispersion of data is accounted for by establishing confidence limits and by undertaking sensitivity analyses. Thus, numerous factors may be combined in the context of various scenarios.

The output of the model is a prediction of the total cost of a particular acquisition arrangement. However, the reliability of the prediction depends upon the reliability of the estimates entered into the model. The effort of the authors in reworking previous studies does add to the confidence which can be placed in the estimates. However, even if all the estimates were highly unreliable, the model still would be able to determine which variables drive the cost and what the upper and lower cost bounds on the problem are likely to be.

Estimating the Model's Parameters. In order to use the proposed model, in a predictive sense (rather than just to evaluate completed programs), three questions must be answered.

- What has been the typical profit rate reduction due to competition? (A to B, in Figure 2.2-2)

- What has been the typical percentage cost reduction due to competition? (B to C in Figure 2.2-2)

- What has been the typical improvement in the learning rate due to competition? (C to P_2 in Figure 2.2-2)

The most direct procedure for obtaining such data is to estimate learning curves for firms which participated in a program both as a sole-source producer and as a competitive producer. The curves could be estimated for either unit cost or price, as long as the profit rates were available. Several data points on each curve would allow calculation of profit, unit cost, and learning rate changes. Unfortunately, previous studies invariably combined all such changes into one number. Because of their incomplete theoretical models, the data they gathered are not adequate for use in the current model. For example, some studies computed only the change from final sole-source price to competitive price, using that as an estimate of percentage changes. However, such an approach ignores what the sole-source price would have been and what change in learning occurred. Thus, such data cannot be used to evaluate or to predict.

Other studies determined the total contract cost under competition and estimated what the cost would have been under sole-source production using a learning curve approach. This approach properly estimates the value of competition in the past, but it cannot be used to predict, because it does not separate out the individual sources of price reduction (cost, profit, and learning). Thus, there are insufficient data in even the better studies.

To address the data problem, the authors reworked the data from a prior study of a leader-follower missile program. One problem encountered was that only competitive profit rates were established; the study estimated the sole-source profit rate. Further, it was somewhat unclear at which point competition should have been considered to have had an effect. Making judgments about these and other problems, the authors were able to estimate sole-source and a competitive learning curves for an individual firm. The results were:

- The profit rate reduction produced a 4% savings

- The unit cost reduction produced an 8% savings

- The improvement in the learning rate produced a 5.5% savings.

The total savings is 17.5%. The authors examined a total of 45 programs and found an average savings of 33 ± 6% savings. The savings on seven missile programs averaged 13 ± 11%. (IDA recently analyzed 31 programs and found an overall average savings of 35% and an average savings of 17% for nine "missile or major missile subsystems.") Thus, the 17.5% estimate is not grossly out of line with other programs and other studies. However, it is important to remember that the 17.5% figure cannot be applied to other programs directly. The learning component of the savings must be applied separately, since it depends upon the number of units produced. There also is reason to believe -- in the authors' judgment -- that the combined 12% profit and cost reduction is too low. However, further data will have to be acquired in order to obtain a useful breakdown of savings by category.

The 5.5% total savings resulting from an improved learning rate (in the data above) was based upon an approximately 5% improvement relative to the single-source learning rate.

The 5% learning rate improvement also is not totally different than either Scherer's findings regarding War II bomber programs (4.4% improvement for competitive sources) or the data obtained by the authors on four recent missile acquisitions with competitive production sources (3.9% improvement for competitve sources). Thus, a reasonable estimate is taken to be 5 ± 2%.

In order to obtain preliminary results, the following parameter estimates (with 90% mean confidence limits, based upon the data dispersion) are used:

- Profit and cost reduction (combined): 12 ± 2%
- Improvement in sole-source learning rate, as a percentage of that rate: 5 ± 2%.

Several points should be noted. First, as mentioned above, the 12% is very likely too low. Second, the results of previous studies are not relevant for prediction purposes unless their sources of savings can be specified. Third, none of the previous studies provided either a totally adequate evaluation or a useful predictive result, because of the inadequate theoretical structure. Fourth, although more data are required to obtain better parameter estimates, the data needs are well defined and fairly unsophisticated. Fifth, even though the conservative parameter estimates are used, under assumptions reasonable to an example missile production program, substantial benefits to competition are predicted.

Example Case. The following example case is intended to provide conservative, preliminary results for a hypothetical missile production program and to demonstrate the capability of the model to perform sensitivity analyses. The following assumptions provide the basis of the example.

Assume:

- Two firms compete for production, with a 60%/40% production split
- Each firm has an 89% learning curve
- $1 million is the unit cost at end of first production run
- Missiles will be produced each year for eight years; in total, 3500 missiles will be produced
- Start-up and technology transfer costs are $20 million (both are taken as one-time costs)
- The learning curve shifts downward 12 ± 2% and improves 5 ± 2% from its initial rate
- Differential O & M costs are zero.

Results are obtained under both 0% and 10% inflation assumptions. Both sole-source and multiple-source total costs to government predictions are obtained. The results:

Acquisiton By	Total Cost (in millions of dollars) 0% Inflation	10% Inflation
Sole-Source	2,570	3,920
Multiple-Source	1,612 [1,941 ↔ 1,337]	2,426 [2,936 ↔ 1,999]
Approximate Net Savings from Competition	958 [629 ↔ 1,233]	1,494 [984 ↔ 1,921]

Depending upon the actual inflation rate and given the somewhat conservative parameter estimates applied to the model, it is reasonable to predict production cost savings of about 1.5 billion dollars in this example case. It is expected that further empirical research, leading to refined parameter estimates, will produce greater predicted savings.

Further, it should be recognized that the predicted 1.5 billion dollar savings are based on specific program assumptions which, if modified, would affect the predicted savings figure significantly. For example:

- An increase in planned production quantities would increase predicted savings
- An acceleration of delivery schedules would be facilitated in the multiple source case, with increased predicted savings
- A combined acceleration and expansion of production quantities would compound predicted savings.

Finally, it should be noted that the 1.5 billion dollar savings could fund procurement of more than 2,000 additional missiles, under the constant budget assumption.

5. CONCLUSIONS

Although numerous studies have attempted to estimate the impact of competition on weapon system production costs, the results have not been completely reliable. Typically, inadequate theoretical models were used, overlooking extensions in the sole-source learning curve and shifts in the slope of the curve. In some cases, the total production run was used as a base for estimating the savings, rather than just the portion of the run which was competitively produced. Finally, the distinction between evaluating the past impact of competition and predicting its impact on future programs was not properly drawn.

The authors have constructed a theoretical model which could be used predictively. However, the data were not available except in one previous study. Thus, it was necessary to draw conclusions from an inadequate data base. However, since the model was constructed to perform sensitivity analyses, production cost estimates can be obtained for a variety of assumptions, and confidence limits can be established.

In summary, the authors:

- analyzed previous studies and reworked the existing data
- developed a model for evaluating, predicting, and performing cost sensitivity analyses
- established a set of assumptions related to an example missile program
- obtained a preliminary estimate of the savings due to competition for the illustrative case.

6. ACKNOWLEDGMENT

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ENHANCEMENT OF COMPETITION IN THE DEPARTMENT OF DEFENSE

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ABSTRACT

Over the years, competition in the contracting and acquisition process has been considered to be the key ingredient to assuring lowering prices and reasonableness in the marketplace. It has been through the development of customer requirements and the dynamics of the available market in meeting those requirements that prices and performance are enhanced and technological innovations advanced. As a result, the Defense Acquisition Regulation and the Federal Procurement Regulations require that all procurements whether by formal advertising or by negotiation shall be made on a competitive basis to the maximum practicable extent.

Continuing efforts at all levels of Government have been initiated to increase the levels of competitive contractual purchases. Yet, current data indicates a steady decline in competitive contractual actions has been experienced by the Department of Defense over the past 15 years. As a result of this steady decline, the DOD authorized Don Sowle Associates, Inc., to perform a comprehensive management study of DOD's current acquisition/purchasing/contracting regulations, policies, and procedures to provide recommendations for increased price competition.

This study included a myriad of areas and the entire spectrum of acquisition within DOD. Examples are: 1) methods of motivating Government personnel; 2) multi-year contracting; 3) contractor support; 4) use of performance versus design specifications; and 5) elimination of any real or perceived impediments to price competition.

The project focused on the above areas but was not limited from seeking innovations to enhance competition. To date, the conclusions and recommendations of this study are only in the formulation stage but preliminary findings indicate a vast potention for the enhancement of competition.

THE PROBLEM

Current acquisition data available to DOD indicate a continuing decline in the rate of competitive contract awards over the past 15 years. The rate declined in fiscal year 1978 by nine percent and dropped over 50% since 1965. Due to this trend, these statistics, and continuing concern by DOD, Congress and the general public, innovations are continually being sought to reverse the trend.

The reasons for the declining rate are easily understood. The reporting system is extremely complex, there is an extremely wide variety of transactions, and the requirements to use Government purchasing in furtherance of socio-economic objectives, are highly influential factors. This mix of products, business arrangements, and directed sources has reduced or clouded the meaningfulness of the statistics. As a result, and along with other initiatives, the DOD recently awarded a study contract (4 September 1979) to Don Sowle Associates, Inc., (DSAI) of Arlington, Virginia, to seek means by which to enhance competition for DOD supplies and services. More specifically, the study required a review and analysis to determine the causative factors leading to this steady decline and to identify remedial methods that potentially will lead to an increase in competition for the entire spectrum of DOD acquisitions.

The factors which seemingly have inhibited competition are, for the most part, well known. All have some validity. They include claims of a lack of sufficient data; lack of resources to develop new sources; a tendency to be wary of untried sources; standardization; valid sole source requirements; and the old standby, "The acquisition process is too complex." Further, users' insistence that the product or service of a particular contractor be provided, has been a major factor, as is the tendency to select a contractor who has been performing highly specialized research or other work for an extended period.

The declining rate of price competition in the DOD may have one or many causes, as those above, that must be identified and rectified to restore confidence of the Congress and the public, as well as DOD managers, in the contracting process. The causes have been either promoted or condoned by acquisition/purchasing regulations, policies, procedures or methods that evolved in implementing the statutes that now guide the process. Reversal of this trend requires identification of the specific documents and circumstances leading to the declining rate, as well as the personal incentives and management emphasis needed to promote competitive procurement.

METHODOLOGY

This research project was designed to identify and evaluate those aspects of the acquisition process that contribute to noncompetitive

acquisition decisions. In addition, to seek alternative solutions that would enhance competition, primarily by determining the acquisition strategies followed in individual noncompetitive acquisitions at selected purchasing activities in the Department of Defense. These actions were followed by interviews with knowledgeable individuals involved in the acquisition process generally, as well as in the specific contract actions selected for review.

The random contact sampling and activity selection process was undertaken initially by securing a DOD printout of DD Form 350 data on individual noncompetitive purchases over $10,000 in FY 1979 at 25 major purchasing activities located in eastern United States. This printout included only those awards representing definitive contracts in FY 1979 as distinguished from modifications to existing contracts. It excluded all noncompetitive awards that were follow-ons to earlier competitive awards.

Analysis was then made of the numbers and dollar values of noncompetitive awards, the basic missions of the activities, and the authorities cited for negotiation in lieu of advertising, to derive a contract review base considered adequate within study constraints.

Three service locations were selected for making a pilot review of contract files, conducting interviews, and identifying causes of noncompetitive purchasing as applied to specific acquisition circumstances. The contracts identified for initial review at those activities, and for later review at others, were selected at random from the total printout for each activity. These selections were made within negotiation authority groupings, so as to provide a representative sample.

On the basis of initial visits and preliminary findings, particularly with respect to time-consuming issues of questionable coding under the Procurement Actions Reporting System (PAR), plans for future visits were revised and a final list of 15 activities determined.

Advance notices of proposed visits were sent by the Office of the Under Secretary of Defense for Research and Engineering, and each activity was provided an advance listing of contract actions selected for review.

The total number of definitive awards made in 1979 without competition, excluding follow-on and modifications, by these 15 activities was 6,964. The total value was $3.6 billion. From those, a total of 378 awards with a value of $744.5 million were reviewed. Thus, for the category reviewed, the sample encompassed 5.4% of the actions and 20.6% of total dollars out of those activities.

A developed study plan and interview guide contemplated that circumstances inhibiting competition in the specific award actions reviewed would be discussed with appropriate personnel at each activity. This was done. The objective was to find practical alternatives to noncompetitive contracting. For example, through (i) better advance planning, (ii) changes in the budgeting and funding processes, (iii) changes in basic acquisition methodologies in designing new strategies, or (iv) placing more emphasis on use of particular existing acquisition techniques and other available tools, the competitive process might be enhanced.

The study plan also called for consideration of published materials and strategies bearing on competition, as well as a wide range of special subjects, most of which were addressed to some degree during the study. However, limitations in time and funds did not permit extensive study of all subjects. Moreover, many subjects had little or no significance at some activities visited. The subjects investigated included:

- Consideration for the concept of A-109 in major systems and less than major systems.
- Acquisition of commercial products in lieu of special design products and use of commercial distribution channels to the point of use.
- Contractor parts support provided directly to the point of need.
- Complexity of solicitation packages that inhibit competition.
- Imposed socio-economic requirements that differ from the marketplace.
- Requirements for quantified evaluation criteria that preclude consideration of significant factors that are not easily quantified.
- Differences in use of terms and perception with respect to competition, methods of contracting, evaluation, etc.
- The wording and interpretation of regulations and other guidelines.
- Budgeting and funding practices.
- Use of performance specifications in lieu of detailed specifications.
- Attitudes of acquisition and contracting personnel that are disincentives to considering alternative competition sources.
- Use of multiple award schedule type contracting.
- Incentivizing Government and industry personnel to increase competition.
- Multiyear contracting as a means of increasing competition.

On completion of all visits, information gathered was correlated, synthesized, and analyzed. The result of this effort, and of reviews of published material, has been developed into specific findings, conclusions and recommendations to be finalized and published in early summer 1980.

PRELIMINARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The subjects investigated were so diverse it was decided that a report should be structured to contain a number of mini-reports. Each subject area was addressed separately with its own findings, conclusions and recommendations, to permit the separate and distinct study of each area. The mini-reports were as follows:

The Procurement Action Reporting System (PAR). Review of the study sample actions through the PAR, DD350, revealed numerous coding inaccuracies or conflicting interpretations, that have tended to distort the trends and current portrayals of procurement action data. In view of the significance of this area, the study team devoted more time than had been originally budgeted.

It was found that 19% of the 378 cases had been miscoded. This percentage represented 59.9% of the total dollars included in the sample.

As presently structured, the reporting system was considered inadequate for representation of the true competitive picture. This situation coupled with a general misunderstanding of, and to some degree apathy in application, has not provided management with information needed for control of competitive procurement actions.

Conclusions

1. Miscoding of DD 350 data reflecting the extent of competition in DOD contracting is widespread and significant. This has caused a major distortion of published data on price competition and on follow-on awards after competition.

2. There is widespread misunderstanding and some degree of apathy in the PAR process that stems from (i) lack of appreciation of the need and value of the system, (ii) conflicting interpretations of coding instructions, (iii) the burden of researching the ground rules in questionable cases, and (iv) inadequate training.

3. The display of DOD statistics does not portray those situations where sole source actions are created due to the advancement of national policies over which DOD has no control.

4. Current contract files have not generally contained an adequate history of prior contractual actions to aid in determining whether an action was competed in the past, thus requiring a coding of follow-on to competition rather than noncompetitive (sole source).

5. The coding instructions in DAR require clarification or expansion with respect to criteria for classification of noncompetitive follow-on awards (after initial competition), and for classification of competitive awards based on multiple-source solicitations and receipt of only one offer.

6. Present requirements for the reporting of small purchases in the PAR system make no provision for presenting the extent to which purchases of $10,000 or less were made, either on the basis of competition other than price, or as noncompetitive follow-on to previous awards based on competition. These figures ultimately are lumped together with DD 350 Code 5 data in published DOD annual statistics. Also, many small purchases are negotiated under the authorities provided in DAR 3-201 through 3-217, where they represent modifications of existing contracts. Where the basic contracts being modified were coded on the basis of technical or design competition (Code 2) or as noncompetitive follow-on after competition (Codes 3 and 4), the "small purchase" add-ons will ultimately also show up in the DOD totals covering Code 5 data and further distort the statistics.

Recommendations

1. Revise DAR Section XXI as follows:

a. Expand DAR 21-126(c)(1) to clarify the coding instructions concerning competition where only one source responds, with examples of when or when not to code as price competition. Change the permissive nature of this coding to mandatory.

b. Expand DAR 21-126(e) to indicate that the time elapsed or the number of intervening follow-on contracts between the initial competitively awarded contract and the current noncompetitive award does not alter the requirement for coding actions as follow-on after competition (Codes 3 and 4, Item 18, DD 350). Additional specific examples of follow-on awards should be provided.

c. Redefine the term "follow-on contract" in DAR 21-126(e) to include (i) contract placement "necessitated by prior procurement decisions made by the purchasing activity, or defense agency, or Federal civilian agency other than the current purchasing activity, and (ii) contract placement direct with firms for the same items previously furnished by them as subcontractors, where such placement is "necessitated by prior procurement decisions." That is, unless competitively awarded, code those awards the same as would be the case if they were to continue to be made to the original prime contractor. Include specific examples.

2. Revise the DD 350 by printing on the reverse side thereof, for ready coder reference, the instructions, interpretations, and examples contained in DAR Section XXI, for the coding of the "extent of competition in negotiation" (Item 18) and such additional instructions as may be appropriate with regard to other coding matters.

3. Give consideration to the relative cost, burden, and value of providing for (i) a new coding in Item 11, DD 350, for commercial products and for automatic coding of these actions as price competitive (Item 18, DD 350) where certified cost and pricing data are not required (Item 19, Code B, DD 350); or (ii) the coding of single source commercial product acquisitions as price competitive where prices paid are no more than published catalog or market prices; or (iii) the establishment of a new coding category under "Extent of Competition in Negotiation" (Item 18, DD 350) to indicate commercial product awards.

4. Revise the DD 350, Item 16 or 18, as

appropriate, and provide necessary instructions either in DAR 21-124 or 21-126, to reflect instances where affirmative efforts were made to obtain competition (beyond the required synopsis in the Commerce Business Daily) but competition was not forthcoming, resulting in a designation under DD 350, Item 18, as Code 5, "other noncompetitive."

5. By recognized and acceptable random sampling techniques, ascertain the approximate number and dollar value of small purchases annually that: (i) are awarded on the basis of design or technical competition or represent noncompetitive follow-on to competitively awarded contracts, or represent supplements of $10,000 or less to existing contracts; and that (ii) are lumped together with noncompetitive awards over $10,000 (Code 5) in published DOD statistics concerning competition. Based on established credible error rates, apply an appropriate adjustment factor to those small purchases classified as noncompetitive and reallocate appropriate numbers of actions and dollars to the DOD totals published under the headings (a) design or technical competition and (b) follow-on after price or design competition.

6. In publishing DOD statistics, break out and separately display in a new category those purchases for which competition is effectively precluded, or is intentionally avoided, in order to support national policies. Include, for example, the following categories: (i) awards to educational institutions pursuant to the 5th Exception to requirements for formal advertising, or those awards representing support of Federal Contract Research Centers; (ii) awards to the Small Business Administration pursuant to Section 8(a) of the SB Act; (iii) awards to utility monopolies (rates fixed by law); and (iv) awards for items in short supply for which no effective competition is possible (e.g., petroleum products, if applicable).

7. Prepare a handbook or coding guide for training and daily use that elaborates on the guidelines published in DAR Section XXI. Prescribe its use in training programs and by all individuals involved in the DD coding process. Accuracy in preparing the DD 350 cannot be overemphasized. Procedures for quality control should be considered.

8. Inform the Services and Defense agencies of the findings in this report pertaining to coding issues, identify problem areas, furnish interpretative material, and stress the need for emphasis and corrective action in the PAR process.

9. Require in the DAR (or otherwise establish and require) an overview or after-the-fact spot check of the correctness of codes assigned in high-dollar awards (e.g., individual awards of more than $50 million).

10. Examine the extent and causes of miscoding of FY 1979 contract actions that represent orders under contracts or other modifications to contracts awarded prior to FY 1979 (see DD 350, Item 14, Codes 4, 6, 7, and 8).

Factors Inhibiting Competition. Many of the forces that drive and influence decisions for competition in the acquisition process are well known. The value of reliance on proven sources, the absence of technical data and the cost of acquiring and evaluating it, the avoidance of lost time and unnecessary duplication of costs, the desirability of continuity of contract effort, mobilization base needs, and limitations on Government resources, are just a few. All have validity. This study examined the reasons assigned in each of the 378 sample acquisition actions.

The following factors were identified as key elements inhibiting competition:

1. Lack of data (manufacturing drawings and processes, and test data). Frequently it is difficult to state requirements in terms adequate for price competition on the basis of data at hand. Moreover, there are dimensional and performance characteristics, quality and durability needs to be met, that call for costly testing. If required quantities needed were larger and appropriately funded, then consideration of the value and feasibility of requiring data for future competition can be pursued.

2. Lack of resources. A general concensus of thought was that if more resources were available, greater competition could be achieved. If more resources were available including time, identification and evaluation of the costs of needed data, negotiation of data needs, resolution of proprietary rights, examination of correctness and adequacy of data delivered, and reporting of data could be accomplished.

3. New sources cost time and money. Interruption of ongoing effort, such as R&D or operational support, in order to introduce competition in successive years, was judged to have significant cost and time impact if new sources were to be selected. In those cases where this adverse impact could be demonstrated, and where the incumbent was performing well, it was felt no useful purpose could be served by competitive action and getting a new source up to speed. The feeling was the incumbent would win on merit anyway, and the competition might well be labeled as "phony."

4. New sources are risky. It was felt that proven sources must be used for critical items. Purchases from "low bid" sources that have not previously supplied the items needed could have serious readiness consequences. Pre-contract qualification or pre-production testing can be costly and time-consuming, and lead to serious contracting problems.

5. Standardization - repair parts - obsolescence. There were many circumstances in which purchases of replenishment parts from the

original manufacturer was accomplished to assure interchangeability. It was also found that reliance was placed on the original producer for parts that had become obsolete, and it was not practical for other suppliers to produce parts to meet those needs in the repair of equipment they had not manufactured.

6. Complexity of the acquisition process. Complexity of the process was stressed repeatedly as a major factor inhibiting competition. This complexity affects both the Government and industry. From the Government view, requirements to prepare detailed acquisition plans and source selection criteria with all attendant documentation, plus the special review and coordination processes, tend to encourage non-competitive purchasing. From the industry view, solicitations and the myriad of requirements to be met in submitting proposals are complex, confusing, and "not worth the effort" in numerous cases. The complexity issue is discussed in greater detail in a separate segment of this study.

Findings. Principal reasons advanced to justify noncompetitive hardware acquisitions involved:

1. Insistence by users that the end product (or part) of a designated manufacturer be purchased from him because (i) no one else made the identical item; (ii) standardization needs were critical (e.g., parts interchangeability); or (iii) assurance was lacking that a new producer could or would produce a product of satisfactory quality, performance, and interchangeability.

2. Absence of adequate data (drawings, etc.) to describe specially designed items or commercial replacement parts, necessary for purposes of competition.

3. Failure of the requiring activity to provide information to the purchasing activity, such as (i) identity of actual manufacturer of parts (as distinguished from the end item prime contractor); (ii) whether the product is sold commercially; (iii) end use and environment of use of the item; and (iv) criticality of use.

4. Coupled with the above, lack of resources to support (i) investigation of value of acquisition of data and data rights; (ii) data analysis (determination of adequacy) and continuing update; (iii) new product qualification and testing; and (iv) adequate market research for alternative sources.

5. Acquisitions meeting criteria set forth in DAR for (i) avoidance of duplicating investment (time, facilities, start-up costs), and (ii) maintenance of the mobilization base.

Principal reasons advanced to justify noncompetitive acquisition of services, including R&D, involved the following circumstances:

- The required effort was an outgrowth or offshoot to work previously performed by the contractor.
- The required effort represented continuation of work (follow-on) previously contracted for on a noncompetitive basis.
- The award was based on an unsolicited proposal.

With regard to the first two categories, reasons advanced to support noncompetitive action were quite similar in all cases and involved the following considerations:

- The contractor had been performing the same or similar highly specialized research or other service for an extended period in the past.
- No other contractor possessed equivalent experience, background, or familiarity with the intricacies of the particular defense program or sub-element thereof.
- Introduction of a new contractor would result in losing the experience, knowledge, and expertise developed by the incumbent contractor. This would cause substantial delays or interruptions in completing essential tasks, as well as duplication of costs involved in bringing the new contractor "up to speed."

The above reasons may be likened to the criteria established for the use of the 14th negotiation Exception contained in DAR for requirements for formal advertising in the acquisition of technical or specialized supplies requiring substantial initial investment or extended preparation time for manufacture.

The files of the sample cases examined did not usually provide back-up data supporting the conclusions reached, such as (i) a more precise explanation of how readiness would truly be adversely affected by a delay; or (ii) calculation of estimated excess costs in going to a new contractor and how derived; and (iii) what demonstrable benefits might be expected.

The validity of claims of time lost or additional costs incurred were apparently not challenged on either a general or a specific bases, in the cases reviewed. It does appear possible that the adverse impact of these cost/time factors might be outweighed by the expected advantages of competition, even where the incumbent contractor is ultimately successful in competing for the new work.

These issues are particularly significant where there has been a succession of added work or continuation of effort extending over several years. Instances were found where initial small awards (competitive or not) of much less than $100,000 gradually grew over the years, on a noncompetitive basis, to annual funding levels of hundreds of thousands, for other than major systems development.

Conclusions

1. At all activities visited, based on the limited sampling of files, no instances were found

in which clear, practical, and advantageous alternatives to noncompetitive awards were available under the circumstances prevailing at the time of solicitation.

2. Statements justifying noncompetitive contracting on the basis of need to avoid delays and incurrence of additional costs were rarely challenged, or if challenged they were not documented.

3. Requiring activities often do not provide sufficient data to enable the purchasing activities to determine or develop opportunities for competitive acquisition of replenishment spare parts.

4. Repetitive noncompetitive acquisitions are frequently made during many years, using pre-prepared standard forms justifying "sole source" purchases, with no evidence that independent re-appraisals are made.

Recommendations

1. Establish a requirement for periodic and special reviews of proposed noncompetitive acquisitions sought to be justified on the basis of loss of time and dollars to introduce a new contractor.

2. As an alternative to the recommendation above, require establishment of a function at every major purchasing activity, to act on a fulltime basis as Advocate for Competition. The time of this function would be devoted largely to assuring that:

- All reasonable competitive alternatives to a proposed noncompetitive award have been considered, and the decision justified.
- Trade-off analyses (cost/benefit) are conducted.
- The internal operating procedures at the purchasing activity are structured so as to be compatible with and supportive of policies for enhancing competition.
- Plans for future competition are made and executed early in the process with appropriate follow-up.
- Factors or problems inhibiting competition are surfaced and addressed, and corrective action taken whenever possible.

The assigned individual should:

- Be given a free hand in selecting actions for review.
- Report directly to the Director of Purchasing or other equivalent authority at the activity.
- Act as the principal liaison and expert within the activity for competitive actions.
- Serve as a repository for "lessons learned" information.
- Serve as a focal point in liaison with other purchasing activities on competition enhancement.
- Determine the value of and institute local programs designed to enhance competition.

This new function would enable dissolution of any board or committee established solely for reviewing the adequacy of justifications for proposed sole source awards. It may be desirable to rotate personnel assigned to perform this function.

This new function should not be established as a mandatory sole source award review and approval authority. The resultant workload might result in dilution of effort and unduly delay the contracting process. Instead, the assigned individual should be selective in the dollar ranges or types of actions to be examined, consistent with a manageable workload and without adding to the normal time required for contract award.

COMPLEXITY OF THE CONTRACTING PROCESS

At all activities visited, it was evident that the complexity of the acquisition process contributes to non-competitive purchasing.

Policies and procedures applied in competitive acquisitions concerning (i) preparation of specifications or statements of work; (ii) formulating the terms of solicitations; and (iii) preparing source selection and other criteria for determining the best offer, require a far greater burden in paperwork, review and analysis than do non-competitive acquisitions.

There is evidence also of a degree of user uncertainty that competitive awards will result in the least-total-cost and most timely acquisition of high quality products or services to meet critical needs. One motivation is to meet needs with the least in-house burden. Another occurs where there is minimum potential for delays due to protests, disputes, testing, or other necessary processes in contractor selection.

Two suggestions for solution were offered. The first was to seek an increase in the $10,000 ceiling controlling the use of small purchase procedures for formal advertising. The second, and more important, suggestion envisioned a simplified and less formal procedure for acquiring products or services, including R&D, where existing authority is available to negotiate awards over $10,000. Under present statutory requirements, certain mandatory contractual provisions or affirmative action programs cannot be avoided in contract awards over $10,000. Additionally, many requirements are imposed administratively that have questionable value in relation to the potential benefits of using simplified or streamlined procedures.

Another way in which competition is adversely affected by complexity of the process is the

inability or unwillingness of a large segment of industry to cope with the details, legal technicalities, and paperwork involved in doing business with the Government. Solicitations are often lengthy and filled with legalistic provisions designed to protect against a myriad of contingencies, many quite remote. Without obvious advantages to outweigh this burden, the products and services of many highly qualified firms have become unavailable to the Government.

Firms unfamiliar with the potential pitfalls, intricacies, and rigidity of Government contracting sometimes find themselves in serious difficulty. This is not a new problem; it has been the subject of considerable DOD effort and Congressional interest over many years. Reviews of current routine solicitations involving over $10,000 indicate there has not been any significant improvement.

With respect to acquisition of commercial products, attention is invited to a January 1980 study report prepared by Don Sowle Associates, Inc., for the Air Force Business Management Center at Wright Patterson AFB, "Simplifying Contracts for Commercial Systems." That study centered in the acquisition and logistics support contracts for the KC-10 Advanced Tanker Cargo Aircraft system, the F-4 Advanced Airborne Command Post system, and the support contract for the C-9 Aeromedical Evacuation Aircraft system. The acquisition of commercially developed diesel generators also was analyzed. Several recommendations were offered to simplify and improve the acquisition process.

Conclusions

1. The acquisition process leading to awards of more than $10,000 is complex and burdensome.

2. Use of current small purchase procedures in acquisitions over $10,000 but not exceeding $100-000, for example, would significantly reduce complexity. However, some modification to that procedure would be required to accommodate the mandatory features of certain statutes applying to contracts over $10,000. Synopsizing would also be necessary under the Small Business Act.

3. As a rule, under present policies competitive negotiation provides no advantage over formal advertising where awards are based on price alone.

4. An increase in the present negotiation authority ceiling of $10,000 would enable the use of small purchase procedures in cases where negotiation authority is not otherwise available.

Recommendations

1. Conduct a study of feasibility, extent, and benefits of proposed use of simplified purchase procedures for purchases of more than $10,000 but not exceeding $100,000. The objective would be to redesign the simplified purchase procedures to accommodate requirements of law, yet reduce the present administrative burden.

2. Propose to the Office of Federal Procurement Policy the amendment of the Armed Services Procurement Act, to raise the ceiling of $10,000 under Section 2304(a)(10), to $25,000--or at least to a level that recognizes inflationary cost growth since 1974.

PURCHASE OF SPARE PARTS

A sampling of purchases at several buying activities revealed that spare parts comprise a significant portion of the sole source purchases. At depot type activities nearly all sole source purchases are for spares. Purchase of spares appears to be a major contributor to declining rates of competition as new equipment is fielded and increased support costs are encountered through sole source contracting.

Sole source purchase of replacement parts or components was based primarily on a lack of data that would enable solicitation of competitive offers. Buying activities at depots far removed from the point of use have little more than a manufacturer's part number and a company name. Buyers are inhibited from considering any item not first approved by the user. They generally do not know whether the equipment prime contractor or a subcontractor made the part; if the part is sold commercially, and if so whether it is modified for military use; or the end use, environment, criticality, or function of the part.

When the above unknowns are present the only option available is to buy from the original supplier. Additionally, when the procurement method code cited in the computer-generated purchase request indicates sole source, there is no way for the buyer to evaluate the basis for this decision.

Depot buying activities indicated they could do a better job if more data were available to enable them to obtain competitive offers. Since a review of the results of using technical data in making competitive purchases of spares was not made, there was no way of determining the benefit or impact of that procedure. However, several examples were mentioned where attempts were made to have a competing firm use technical data purchased from the developer, with unsatisfactory results.

The review of sole source purchases of spares shows that early decisions concerning the original equipment severely limited the alternatives available for enhancing competition. Any availability of information concerning the original acquisition and end use application have traditionally limited depot buyers.

A major factor to be considered in purchasing replacement parts or components is whether the original equipment or component is of special design, or is a commercial or standard product. When equipment is designed for special application, suitable design drawings and specifications may not be available for competitive reprocurement, even though the research and development was by Government contract. Likewise, special design

equipment life cycles will in most cases be of sufficient length to benefit from Government depot parts support. Conversely, commercial product parts are more likely to be available through competition in the marketplace with cost effective distribution available through commercial channels. Thus it would appear that separate procedures should be applied in developing strategies for provisioning, cataloging, and Government stocking of replacement parts for special design equipment as opposed to support for commercial products.

Since logistics support decisions have such a long range impact, alternative ways of purchasing replacement parts, and the cost/benefit analysis of the Integrated Logistics Support (ILS) strategy should be emphasized at the time of equipment acquisition.

In many cases there is need for a periodic reappraisal of the "up-front" decision-making process. This would help preclude placing a depot buyer in a position where there are no options aside from the original equipment manufacturer as sole source.

DOD Directive 5000.39, "Acquisition and Management of Logistics Support for Systems and Equipment," January 17, 1980, provides for review and assessment of alternative strategies to support the operational requirement for the system at lowest life cycle cost. DODD 5000.39 also indicates that:

> "Full consideration shall be given to current maintenance, initial provisioning, and supply support policies, systems, capabilities, and procedures....Innovative support concepts to improve system readiness support costs are encouraged...."

The sample of spares purchased indicated that requirements and procedures subsequent to initial provisioning did not have the benefit of preplanning at time of systems acquisition. A separate in-depth review should be made to identify specific improvements for the spares acquisition process.

<u>Spares for Commercial Equipment</u>. Prices charged for commercial equipment support and commercial parts are generally based on catalog or market prices. As such there are many alternative ways of structuring solicitations to pre-price parts and services with original competitive equipment purchases. Firms specializing in this kind of business will compete against one another and negotiate with the OEM or parts manufacturers to obtain items.

The following alternative systems may be developed with OEM parts or parts manufactured in support of the commercial aftermarket:

- Competitive contracts with companies having a distribution capability for parts support of a system or item of equipment to the point of need.
- Functional support contracts where a supplier provides full parts support for a function, such as a repair shop.
- Negotiation of prepriced parts catalogs as part of the equipment acquisition. The catalog may then be used by the using activities dependent on the terms of delivery.
- Full or partial maintenance contracts, including parts.
- Leasing of equipment (or components) for short term or supplemental requirements, with the lessor providing all maintenance and spares support.

<u>Spares for Special Design Equipment</u>. Conditions associated with parts support for special design equipment differ significantly from those encountered with commercial products. The differences apply mainly to lack of a marketplace price base and commercial distribution systems that serve many customers rather than the single Government user. The Government does, however, have access to product cost data and may also have equity in technical data and tooling used to produce the parts. Initial provisioning negotiations will have development and production cost data available; but subsequent purchases, especially when made by a different purchasing agency, will be without cost data or competitive leverage. Therefore it is essential that the strategy for spare parts acquisition be developed as part of system or equipment acquisition and that business arrangements provide for carrying out the strategy.

Possible competitive arrangements to acquire special design repair parts and components can be:

- Included as part of the basic equipment or system acqisition contract, or
- Planned initially by providing for acquisition of technical data and tooling for spares to be acquired separately.

The most fruitful means of using competition in acquiring spares for special design equipment would be to include multiyear spares requirements as part of systems or equipment acquisition. It would be competitive among prospective prime contractors and between the selected prime and the alternative of breakout. The results of these negotiations would provide the basis for subsequent competitive negotiations with alternative suppliers for those items of special design where a decision is made to acquire data for subsequent competitive procurement. Initial provisioning would generally be part of system acquisition.

The benefits of buying spares from the initial manufacturer or in making arrangements for

procurement data on breakout items as part of systems acquisition are that:

- All spares would be competitively procured.
- Decisions on breakout would be made at a time when current design/cost data are available.
- The breakout decisions and supporting rationale will establish a baseline of procurement history that is essential for making good subsequent decisions on sources, costs, quality, configuration and warranty.

However, in arranging for spares at time of systems or equipment negotiations, there are numerous problems, a lack of resources to estimate requirements, evaluate alternatives, and conduct negotiations. Additionally, lack of funds, time and data create a tendency to delay arrangements for spares until equipment is fielded. It was found in some cases even initial provisioning was done on a sole source basis.

Conclusions

- The largest single area of sole source purchasing at DOD depots is for repair parts.
- Spare parts buyers, especially those at depots and agencies, are faced with buying items by part number without knowing the end use application, if the item is commercial or of special design, and what company actually manufactured the items.
- Conditions that lead to sole source purchasing of repair parts are established during acquisition of systems and equipment that require maintenance and repair parts support.
- DODD 5000.39 (Integrated Logistics Support) encourages consideration of innovative maintenance and supply alternatives but the established supply and procurement system fragments responsibility and the decision-making process.
- Since commercial products, parts and components are manufactured, distributed and supported through a competitive marketplace structure, those spares should be separately identified at the start of the equipment acquisition process so that competitive commercial alternatives can be properly considered.
- Business arrangements for acquiring spares from the Original Equipment Manufacturer should be considered as part of the equipment acquisition on a multiyear basis.
- Special design parts and components selected for breakout, second sourcing, or competitive procurement should be an element of system or equipment negotiations with appropriate technical data provided for as developed.
- Acquisition strategy for special design parts and components should be developed for each system on a least-total-cost basis.

Recommendations

- Establish procedures for acquisition of commercial equipment to provide for making best use of products, distribution systems and business practices of the marketplace in implementation of DODD 5000.37.
- Establish requirements for designing acquisition strategy for commercial products to include spares support for equipment on a least-total-cost basis including consideration of commercial distribution systems and practices.
- Include various support techniques in DODD 5000.39, such as functional support contracts that encompass all parts and supply needs of a maintenance function, as alternatives to spares and provisioning for specific items of equipment.
- Revise DODD 5000.39 to specifically identify alternative contracting strategies that have proven to be effective in acquiring spares as part of equipment acquisition.
- Develop guidelines for selective equipment breakout and acquisition of technical data on special design parts that recognize significant production risk and least-total-cost.
- Require that the procurement history for spares purchased and distributed through Government depots reflect procurement method coding decisions made at time of system or equipment acquisition, and the rationale for the decisions.
- Conduct an in-depth study of DOD spares acquisition policies, procedures and practices to identify alternative contracting strategies and provide guidelines for their selection and use.

MULTIPLE AWARD TYPE CONTRACTING

The term "multiple award contracting" has two meanings. First it can apply to a division of solicited quantities or items among several offerors. Second, it may apply to the GSA/FSS program of multiple award Federal Supply Schedules, where contracts are executed with several suppliers for entire lines of commercial products. Since the term generally is used in discussing the FSS schedules, this report addresses the FSS concept as an approach to enhancement of competition.

The following programs are examples of this concept representing several billion dollars in property value purchased annually by the Government.

- Federal Supply Service multiple-award schedule program. This program was initiated by the Treasury Department over 50 years ago. It

consists of a pricing arrangement with each manufacturer or supplier selling commercial products in the marketplace. Each agrees to provide these same products to any Government ordering activity at an agreed price. The value of orders under this program for fiscal year 1979 was approximately $2 billion. The resulting contracts are available to every Government activity for ordering directly from the supplier without further negotiation. Using activities select the lowest priced satisfactory item from the multiple sources on contract, and place a one-page delivery order with the firm.

- Department of Defense food supply bulletin program. This program is very similar to the Federal Supply Schedule Program, but is for processed foods purchased for resale through commissaries. The solicitation procedures, negotiations, and resulting contracts may differ from multiple-award Federal Supply Schedules, but the use of off-the-shelf competition as a basis for contract pricing is the same.

- Air Force Buy U.S. Here (BUSH) program. This program was instituted in 1962 to provide overseas DOD activities with many off-the-shelf products covered by Federal Supply Schedules in the United States. Contracts are limited to U.S. firms having overseas distribution systems, who can more effectively deliver and service U.S. made products to overseas activities.

Multiple-source Contracting Authority. The FSS cites Section 302(c)(10) of the Federal Property and Administrative Services Act as authority to negotiate multiple-award Federal Supply Schedules. This exception to formal advertising is "for property or services for which it is impracticable to secure competition." An identical exception is included in the Armed Services Procurement Act.

Examples of when this authority may be used are given in the Federal Procurement Regulations (FPR) and the Defense Acquisition Regulation (DAR). These examples include cases where the supplies or services can be obtained from a sole-source person or firm and when it is impossible to draft adequate specifications or purchase descriptions for a solicitation for bids.

Unfortunately the wording of this exception and the examples for its use convey the impression that "competition" is not possible when using this authority. Even the FSS refers to single-award schedules as competitive, implying that multiple-award schedules are noncompetitive. But those managing the multiple-award program indicate that prices are based on marketplace competition with two additional competitive steps achieved, one in the process of contract negotiations and one in product selection at point of use.

Multiple-source contracts come under a type of contract defined in the FPR and DAR as "indefinite delivery." These are prepriced arrangements for a period of time where the quantity is either indefinite or is dependent on Government needs. However, the FPR and DAR do not provide for multiple-source indefinite delivery contracts. Instructions are provided in these directives for placing orders against multiple-award FSS schedules but even there the DAR indicates that the nonmandatory FSS schedules are to be considered "another source of supply." The word "schedule" itself is misleading when referring to one contract rather than a list of contracts.

The question of authority is probably academic since the concept has been used for many years. The General Accounting Office addressed the issue several years ago and concluded that specific statutory authority does not exist, but the benefits to the Government in using the concept sanctions its use.

Discussion

The major issue is the value of using multiple-award type contracts to increase price competition. The first question deals with the term "price competition." The Armed Services Procurement Act uses the term "full and free competition." DAR 3-807 Pricing Techniques defines "price competition" as something that exists:

> "...if offers are solicited and (i) at least two responsible offerors (ii) who can satisfy the purchaser's (e.g., the Government's) requirements (iii) independently contend for a contract to be awarded to the responsive and responsible offeror submitting the lowest evaluated price (iv) by submitting priced offers responsive to the expressed requirements of the solicitation."

This wording precludes award of more than "a contract." Therefore price competition cannot be increased by multiple-award contracts unless the DAR is revised to permit contracts with more than one source for the same type of items.

There is a school of thought that FSS multiple-award schedules are not for identical items, therefore each is a requirements contract for particular items. In view of problems associated with administering centrally issued requirements contracts used by thousands of ordering activities for items to satisfy a wide range of similar needs, it does not appear appropriate to establish these multiple sources as exclusive requirements contracts (RC) as opposed to indefinite quantity contracts (IQ).

S-5, the "Federal Acquisition Reform Act" proposed by Senator Chiles uses the term "effective competition." Since the DAR already clarifies the intent of 10 U.S.C. 2304(a)(10) by adding the words "by Formal Advertising" it could redefine "full and free competition" along the lines of

"effective" rather than "price" competition. This would enable revision of DAR 3-807 to provide for indefinite quantity (IQ) contracts with more than one source when prices are based on catalog or market prices. DAR 3-409(d) Indefinite Delivery Type Contracts already provides for pricing based on discounts from "industry-wide pricing guides or manufacturers price catalogs."

Assuming that the DAR is revised to provide for multiple-source contracting, several benefits could accrue to the DOD.

If the DAR is revised to provide for awards of IQ contracts to more than one source for a product line; if the term "price competition" is revised to reflect "effective competition"; and prices based on catalog or market prices are determined to be effective competition (or the desired negotiation process is considered to be effective competition), then competition could be enhanced or other benefits would accrue to DOD as follows:

- Alternative acquisition strategies would include multiple source contracting when determined to be in implementation of DODD 5000.37 Acquisition and Distribution of Commercial Products (ADCP).
- Competition would be expanded to the extent that items included in the resulting multiple-source IQ contract would otherwise be bought on a sole source basis due to preselection by users or requirements personnel.
- The procedure would provide a mechanism for prepricing of a wide range of products that would be extremely useful in a contingency.
- The procedure would reduce resources now expended in cataloging and in single item management, since multiple-source IQ contracts would carry commercial descriptions and manufacturers' numbers.
- The procedure would enable a wide range of using activities to order directly from suppliers based on the least costly product to fill a particular need.
- The contracts could be cited as a cost effective source for cost reimbursable contractors, including GOCOs, without separate contractor negotiations.
- The procedures would supplement FSS schedules for interagency use of commodities procured by the DOD under national supply system assignments.

It is noted, however, that the GAO, Congress, and the media have on occasion identified "prices" on FSS multiple award schedules as being higher than could be obtained at a discount house by an individual shopper. Therefore, it would be essential that the following actions be considered as part of a DOD multiple-source contracting program:

- Acquisition strategy clearly indicates that decisions to execute multiple source contracts are based on cost effectiveness.
- Pricing clearly indicates that delivery is FOB destination on call by a wide dispersion of ordering offices.
- Where appropriate, minimum quantities are guaranteed to achieve quantity price discounts.
- Have the DAR clearly indicate that ordering offices are encouraged to use the contracts whenever determined to be cost effective, to avoid making the contracts mandatory.
- Develop creditable negotiation procedures and practices to assure optimal pricing of each contract executed.

The DOD procurement action reporting system provides for orders against FSS schedules to be reported as interdepartmental. Assuming that those contracts result from effective competition, the DOD loses the dollar base and value that would improve data reflected in Item 18 of the DD 350. Since delivery orders against these schedules are issued to the supplier by DOD ordering activities and are administered to completion by the ordering activity, it does not seem appropriate to report these actions as interdepartmental. Further, if DOD issued multiple-source contracts with other agencies ordering from them, these orders would not be reported by the DOD.

Conclusions

- It would enhance the competitive process if the term "price competition," wherever used in the DAR, were revised to read "effective competition" with an appropriate revision to DAR 3-807.
- Authority to execute multiple-source IQ contracts should be clarified in the DAR 3-409 as an alternative acquisition strategy.
- There is some question regarding authority to use the 10th regulation Exception for negotiation due to the language of DAR, which is more restrictive than the statute, by use of the word impossible rather than impracticable to draft adequate specifications.
- Procedures for reporting of delivery orders against interdepartmental indefinite delivery contracts should be revised to include the method of competition in Item 18, DD 350.

Recommendations

- Revise DAR 3-807 and other directives where the term "price competition" is used, to reflect "effective competition."
- Revise DAR 3-409 to enable execution of multiple-source contracts whenever determined

to be cost effective.

- Develop guidelines for negotiation and use of multiple-source IQ contracts.

- Revise the PAR reporting system to report delivery orders against interdepartmental indefinite delivery contracts in the same manner as DOD indefinite delivery contracts.

- Revise DAR 3-210.2(xiii) by changing the word "impossible" to "impracticable."

PERFORMANCE VS. DETAILED SPECIFICATIONS

The potential for increasing competition by use of performance specifications is dependent on obtaining bids or proposals from firms that would not normally compete on a particular solicitation. Comments from buyers during this study and from industry as reported to the Commission on Government Procurement, and other acquisition studies, indicate that many companies are inhibited from selling to the Government because of complexity of the solicitations.

The "art" of developing detailed Government specifications evolved through the formal advertising method of purchasing. Under this method the lowest bid receives the award, so suppliers carefully scrutinize the specification for loopholes or ambiguities that will permit them to furnish the "cheapest" product meeting the specification. Specification writers in turn attempt to close all the loopholes and eliminate ambiguities by becoming more and more detailed. This "game" has resulted in the development of complex specifications for simple items such as mousetraps or other common items.

As the negotiation method of purchasing gained respectability due to the complexity of formal advertising, it has also acquired similar complexities in attempting to achieve "price competition" as defined in the DAR 3-807. Since problems associated with detailed specifications and price competition were surfaced, there has been widespread interest in use of performance specifications for Government purchasing to increase competition.

The term "functional specification" has emerged in referring to performance type purchase descriptions. It probably evolved from the minimum requirement of Form, Fit and Function. A recent definition of functional specification was set forth in the "Chiles Bill," S-5:

> "The term 'functional specification' means a description of the intended use of a product required by the Government. A functional specification may include a statement of the qualitative nature of the product required and, when necessary, may set forth those minimum essential characteristics and standards to which such product must conform if it is to satisfy its intended use."

S-5 also uses the term "effective competition" rather than "price competition" to encourage offers based on least-total-cost rather than lowest price.

Additionally, a draft Federal Acquisition Regulation (FAR) part 10, Specifications, Standards and Other Product Descriptions, was published in the Federal Register on 28 September, 1979, by the Office of Federal Procurement Policy (OFPP) for comments. This proposed Federal directive uses the definition cited in S-5 and provides that commercial product purchase descriptions be written in functional terms whenever possible. It also establishes a new numbered specification system called Commercial Item Descriptions (CID). A draft FAR part 11, Acquisition and Distribution of Commercial Products (ADCoP) was also published for comments along with part 10. Part 11 establishes as Federal policy the purchase of commercial products and use of commercial distribution systems whenever these products and systems can satisfy the Government's needs. The objectives of these draft directives were cited in the Federal Register as follows:

(1) Reduce acquisition lead time.

(2) Insure the acquisition of products that meet user needs.

(3) Increase competition for Government contracts.

(4) Strengthen the commercial industrial base.

(5) Reduce unnecessary Government investments in inventories and accompanying storage, handling and distribution costs.

(6) Take advantage of commercial quality assurance, warranties, and installation, maintenance, and repair services.

Commercial Item Descriptions (CIDs) as established in the Draft FAR part 10, are to be simple functional specifications designed to expand competition. Most will be rewrites of Federal and Military specifications based on the realities of the marketplace. They include a requirement that the products furnished be identical in every respect to products sold to the general public, at catalog or market prices.

The DOD has tested use of simple functional type purchase descriptions under the Commercial Commodity Acquisition Program (CCAP). Competition was enhanced for standard commercial commodities such as electrical supplies and common hardware purchased by DLA under this program. Other items such as underwear and bedding were also available from more sources at lower prices under the simplified purchase descriptions. However, limited competition was previously available for these items, so the simple descriptions did not reduce noncompetitive purchases.

The greatest potential for reducing noncompetitive purchases and also expanding alternative offers

may be by use of functional specifications in highly technical commodities such as tools, shop equipment and test equipment where the lowest price may not represent the least total cost.

The solicitation objective in these cases is to attract a wide range of offers so that those offering the "best buy" can be selected. This poses problems of price competition and product evaluation. DAR 3-807 does not provide for consideration of any factors that cannot be quantified under the rules of "price competition." Thus opportunities for considering hardware value factors, even if they are significant, are foregone unless the requirement is so large that source selection board procedures are appropriate as in acquisition of major systems. Requiring or user activities lacking confidence in the purchase process are then left with the alternatives of developing detailed specifications to reduce the offers to those few that are acceptable or to preselect a best buy and go sole source. In either case effective competition may be reduced.

Conclusions

- Purchase descriptions in terms of function or performance as opposed to detailed specifications have the potential for expanding competition by encouraging offers from firms that are inhibited (i) by the complexities of a detailed specification (ii) from offering their commercial product if it is not "price competitive" with cheaper products on the market.

- Use of functional specifications to expand competition and achieve the best buy, where value is not quantifiable, is inhibited by the DAR definition of price competition and the lack of procedures, guidelines, and credibility in using subjective factors in eavluation of alternative hardware offers.

- Optimum benefit in using functional specifications to reduce sole source hardware purchases is dependent on revisions to DAR 3-807 to encourage development of procedures that will achieve effective competition and provide assurance to requiring activities that the procurement process will result in the "best buy."

Recommendations

- Revise DAR 3-807 by expanding the definition of price competition to include consideration of non-quantifiable factors in determining the least-total-cost offer or "best buy." It may be more appropriate to redesign DAR 3-807 around the concept of "effective competition" to avoid inhibitions that are firmly established around the low bid approach.

- Encourage development of procedures and guidelines for hardware evaluation with the objective of achieving credibility in selecting the best buy in consideration of equipment life cycle costs and administrative costs in the acquisition process.

UNSOLICITED PROPOSALS

At present, there is no established means for tracking the magnitude of unsolicited proposals and the resultant contracts. Currently the Individual Procurement Action Report, DD 350, has not provided such information, and generally activities within the Military departments and DLA do not compile data on these actions in any standardized form. The results of this study indicate that approximately 22 percent of the contractual actions at R&D activities are sole source contracts resulting from these unsolicited proposals. However, without a means for proper reporting, effective planning, management or budgeting for these actions cannot be expected.

Sole source contractual awards due to unsolicited proposals are coded in several ways on the DD 350. In most cases these awards are coded under Item 17, "Negotiated under 10 USC 2304 Exceptions (a)(11), Experimental Development, or Research Work"; yet there are numerous cases where (a)(2) "Public Exigency," (a)(5) "Services of Educational Institutions," and (a)(10) "Supplies or Services for which it is impracticable to secure competition by Formal Advertising" are used. Under Item 18, "Extent of Competition in Negotiation," the majority of procurements have been coded as "5, Other Noncompetitive" from which it is impossible to determine the composition of sole source actions on any particular DD 350 data output.

A random sample review of sole source contracts revealed that about 11 percent were awarded in response to unsolicited proposals. However, examination by functional activity disclosed that 22 percent of awards were based on unsolicited proposals received by R&D activities.

It is recognized that the Defense Acquisition Regulation, DAR 4-902, states "It is the policy of the Government to foster and encourage the submission of unsolicited proposals." Historically, use of unsolicited proposals has provided the Government a viable means of obtaining unique or innovative methods or approaches for technical advancement. Therefore, to maximize the use of unsolicited proposals, management emphasis supported by specific, meaningful data should be stressed in this significant area.

During this review it was furthermore discovered that the contract files did not contain adequate information on the genesis of unsolicited proposals. It was difficult to determine the actual development of a requirement from its inception to contract award. The files contained only the justification for negotiation as sole source and in numerous cases the justifications and exceptions were inconsistent from requirement to requirement.

Consequently, the file documentation coupled with the present DD 350 reporting system do not provide a sound data base from which to make sound management decisions on the use of unsolicited proposals and the current reported levels of sole source contractual awards.

There are three fundamental forms of unsolicited proposals received by the Government.

a. Unsolicited proposals providing unique or innovative ideas based solely on the initiative of an individual or contractor.

b. Unsolicited proposals that have been informally suggested by Government personnel such as program managers, project officers or other technically oriented personnel.

c. Unsolicited proposals which would result in follow-on work to existing or completed contractual efforts.

Unique or innovative ideas based solely on the initiative of an individual or contractor is the legitimate purpose of the unsolicited proposal concept and for which the current procedures found in DAR 4-900 are established. It is not designed nor intended for use as a circumvention of normal competitive procurement procedures. Misuse of the procedures to (i) expedite contract actions, (ii) request contractors to write statements of work, or (iii) assure contract awards to known or previously selected sources, are all situations that must be carefully managed to assure integrity in the procurement process and compliance with Public Law.

In various cases it was apparent through review of the contract files and discussions with contracting and technical personnel, that many awards were outside the fundamental intent of the unsolicited proposal program. As a corollary, there are many instances where a proposal has been accepted through <u>solicitation</u> of an unsolicited proposal and subsequently that particular contractor is "locked in" for follow-on contracts as a sole source to the point where competition is no longer feasible for future years.

<u>Conclusions</u>

The Procurement Action Report, DD 350 and other reporting systems employed by the Department of Defense do not provide for the reporting of unsolicited proposals, nor the contracts resulting from these proposals. As a result, there is no means for properly managing this significant area of contracting. Without such data it is extremely difficult to (i) establish goals, (ii) police and manage the award of sole source contracts, and (iii) budget for future years contracting activities to assure and encourage future innovation in support of the technological base of the United States.

Due to the lack of management visibility and the reduced resources, circumvention of the existing procurement system by <u>soliciting</u> unsolicited proposals from known contractors and thereby awarding contracts to selected sources without competition is difficult to control and manage.

Contracting agencies should not be criticized for awarding sole source contracts as a result of the innovation and enterprise of individuals and business. DAR 4-900 encourages this practice as a stimulus to private industry and to garner new ideas. Therefore, separate reporting of these actions exclusive of other sole source actions will help provide a realistic picture of the actual noncompetitive contractual awards based upon other requirements.

<u>Recommendations</u>

1. The Procurement Action Report, DD 350, should be revised to provide for reporting of contract awards due to unsolicited proposals. This data should be reported as a separate and identifiable item.

2. With the available data recommended above, management should encourage true unsolicited proposals and control the solicitation of unsolicited proposals which can be used to circumvent standard procurement procedures at the expense of creating greater levels of competition.

INCENTIVES FOR GOVERNMENT AND INDUSTRY PERSONNEL TO ENHANCE COMPETITION

The effectiveness of special incentives to motivate individuals to achieve desirable objectives will clearly depend on the ability or opportunity for an individual to have an impact on decision-making. In this study, it was found at some activities that technical and purchasing staffs could do very little to cause "breakout" or development of competitive sources, where (i) users have specified a single source, or (ii) data enabling competitive solicitations are neither currently available nor obtainable with existing resources. No doubt there are cases where allegations (as found in documented justifications for sole source acquisitions) are overstated. This was found to occur with respect to:

- Additional costs occurred, and
- Lowered levels of expertise that would apply if a new source were introduced in follow-on situations. This is a judgmental area having a potential for increasing competition.

There is also a potential for special incentives to cause the issuance of competitive solicitations where the result is a foregone conclusion, e.g., the winners will be the same contractors continuing to perform the same work as in the past. Additionally, in those cases where sole source drivers involve equipment or parts having significant and highly critical quality attributes that can have direct adverse effect on readiness through failure (probable or perceived), the issue becomes one of the prudence of competition, i.e., risk versus the value of competition.

Few specific instances were found where the decision to contract without competition was questionable. In nearly all cases, <u>accepting the file data at face value</u>, the reasons advanced

in support of noncompetitive procurement were adequate in light of circumstances prevailing at the time. Moreover, it is difficult to pinpoint particular areas of weakness where the application of incentives could clearly cause an immediate decision to move from noncompetitive to competitive purchasing. Instead, the opportunity for competition and more effective and efficient acquisitions in terms of cost and responsiveness, appear to depend largely on actions taken very early in the acquisition cycle. At this early stage it may not be possible, when taking a particular action, to know whether competition would be available at a later time. Thus, the development and application of incentives criteria to enhance competition in individual cases may be very difficult and complicated. On the other hand, the development of new techniques and procedures to enhance competition probably provides the best opportunity for applying incentives, as distinguished from case-by-case decision making.

There are several ways in which Government acquisition personnel might be motivated to increase competition. These would include:

- Use of established awards programs that provide recognition (monetary awards, in-grade raises, citations) for outstanding effort. This may be implemented to recognize either individuals or organizations for exceptional achievement.
- Establishment of a program within a purchasing activity (or technical activity) that would periodically cite or recognize an individual as being the top performer in competitive effort.
- Establishing a new cash or recognition award program specially designed and publicized with regard only to successes in switching from noncompetitive to competitive purchasing, or for presenting new ideas to enhance competition.
- Periodic posting of contract award data on competition versus noncompetition in the form of large bar charts or other readily readable form, conspicuously placed, that depict progress--good or bad--as measured against "base year" data.

Findings

Nearly all individuals interviewed on this subject reacted negatively to the value of incentive programs to reward or recognize individual effort. The general feeling was that it would be too difficult to attribute a success to the efforts of one individual. Significant shift from sole source to competitive buying would involve decisions and actions on the part of many individuals, not just one. This makes it difficult to establish that a change would not have occurred without incentives.

Conclusion

Considerable effort would be required to structure an incentive program and special award criteria for enhancing competition. Rather than imposing or requiring the initiation of any new program, it is considered preferable to continue implementing existing programs with renewed emphasis.

Recommendation

In a future issue of an appropriate OSD level directive, emphasize the subject of competition and encourage the Services and DOD agencies to make use of existing programs.

THE VALUE OF MULTIYEAR CONTRACTING AS A MEANS OF INCREASING COMPETITION

As described in DAR 1-322, multiyear contracting is a method of acquiring planned requirements for DOD for up to a 5-year period (4 years in the case of maintenance and operation of family housing), without having total funds available at time of award. Multiyear contract quantities are budgeted for and financed in accordance with the applicable program year as reflected in the DOD Five-Year Defense Program. This method may be used for either competitive or noncompetitive contracting. With respect to competitive contracting, award may be based on price only or price and other factors considered. The contractor is protected against loss resulting from cancellation by contract provisions allowing reimbursement of unrecovered nonrecurring costs included in prices for cancelled items. However, the cancellation ceiling for any contract may not be in excess of $5 million unless the Congress, in advance, approves a cancellation ceiling.

As originally conceived, the multiyear (MY) contracting technique was seen primarily as a means of obtaining realistic competition in follow-on situations involving high start-up costs and other high risk factors. These factors discourage or preclude competition where the incumbent producer has already recovered his costs and greatly reduced his investment risks. Thus, his competitive advantage may be overwhelming. With increased use of this technique, it became evident that the MY procedure was also a valuable tool for achieving many objectives other than the benefits of competition. Even where competition could be obtained in single year contracting, maximum assurances of follow-on production continuity and provision for payment of cancellation charges had many advantages, including (i) lower contract costs, (ii) enhancing standardization, and (iii) reduction of administrative costs and burden.

In all these situations, there are still some drawbacks to MY contracting policy and procedures as presently set forth in DAR 1-322. While there are incentives for contractors to compete on multiyear terms, there is a distinct disincentive with respect to delayed recovery of significant costs in the early stages, or first year of production. This is due to the present policy requirement for

level pricing, i.e., requiring identical contractual unit prices throughout the multiyear period. Under a single year contract, a contractor would normally recover production costs in contract prices, including all initial nonrecurring "expense" items other than full amortization of capital item investment. In level pricing over a period of five years, for example, a period extending well beyond the first year might transpire before those initial costs, or any profit, would be recouped. In addition, the learning curve effect as applied to cost projections, and the scope of cancellation change protection, creates contingencies of loss or windfall profit depending on the degree of risk competing contractors are willing to assume. Other serious drawbacks include inflation and unpredictable cost escalation, for which existing escalation provisions in DAR may not be adequate for long term MY contracts.

Findings

1. The subject of level pricing requirements in MY contracting has been examined in some depth by the Logistics Management Institute and the results published in its report of October 1967 under Task 67-20, DOD Contract No. SD 271-30 (DDC No. AD 662403), titled "Multi-Year Processing and Learning Curve Effects." An earlier LMI report of June 1967 deals with MY contracting problems at the subcontract level.

2. Numerous recommendations were made by LMI for revisions to the MY procedure, including the permissive use of step pricing in lieu of mandatory level pricing in appropriate cases where safeguards are employed to insure over-pricing in the early years.

3. None of the award actions reviewed in this study appeared to be suitable for use of the MY technique. There were relatively few high start-up cost cases, and further study would be required to ascertain whether this technique is being used to maximum advantage. However, if constraints were removed in use of MY techniques for services, there may have been many situations where competition could have been introduced to the advantage of Government and industry.

Conclusions

1. In cases of repetitive acquisitions of replenishment parts for logistics support over long periods of time, use of the MY technique could provide an advantage in assuring reasonable prices over longer periods. This advantage might justify the acquisition of data for competitive purchasing of larger total quantities at one time.

2. DAR requirements for level pricing reduce the potential for increasing competition in high start-up cost situations.

3. A re-examination of factors that inhibit the use of the MY technique, including the limitations on its use to acquire services, as well as further study of the current extent of its use, would be desirable.

4. Limitations on the use of "one year" funds to support MY contracting are probably resulting in a significant loss of advantage to DOD.

Recommendations

1. Re-evaluate the recommendations made by LMI, in both study reports cited above, in light of current acquisition policies and practices.

2. Conduct further study to determine the extent of current use of the MY contracting technique, for the purpose of assuring its use where competition and other advantages can result.

3. Re-evaluate the legal and factual basis for limiting use of MY contracting (as set forth in DAR 1-322.1(d)), with particular regard to both the use of "one-year" funds and the acquisition of services, with a view to relaxing or removing those limitations.

CONTRACTING FOR MAINTENANCE OF
GOVERNMENT-OWNED CONTRACTOR-OPERATED FACILITIES

The Services over the years have entered into a variety of Government-Owned Contractor-Operated (GOCO) arrangements that include both cost-type facilities contracts and leases. In some cases these arrangements provide for (i) assumption by contractors of normal maintenance costs that are recovered by them in the prices charged, or (ii) cost and overhead reimbursement, in supply, R&D, or other types of contracts. In still others, such as ammunition loading plants, all proper costs are directly reimbursed, including normal maintenance.

In those cases involving major capital improvement or major maintenance expense, special provision is sometimes made by separate contract or modification of GOCO contracts. These specify the work required to be done by the GOCO plant contractor, or subcontracted in whole or in part. Several non-competitive awards of significant dollar value in this category were reviewed.

Findings

1. In each case reviewed, the reason stated for noncompetitive action was that the GOCO operator must control all work so as to eliminate interruptions to the work.

2. It was not clear why the Government could not make the same or similar arrangements with third parties selected to perform capital maintenance, as are made by the GOCO operator. The effect of this would be to allow the operator an adequate degree of control over third parties working at the plant.

Conclusions

1. Breakout of all or selected portions of

capital maintenance for direct Government contracting, that would otherwise be subcontracted by the GOCO operator, should provide cost and other advantages (e.g., potential for small business set-asides or other preferential awards).

2. It is considered feasible to selectively break out significant capital maintenance work segments under contractual arrangements satisfactory to all parties.

Recommendation

Cause a re-evaluation to be made of the potential advantages and disadvantages of breakout in such circumstances, including any legal issues, with a view to changing the strategy in the future.

PROCUREMENT PEOPLE, PROFESSIONALISM AND ORGANIZATION

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AN ANALYSIS OF WORK PERFORMANCE OF THE CONTRACTING AND PROCUREMENT AND PURCHASING SPECIALTIES

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ABSTRACT

The Federal Acquisition Institute (FAI) has pioneered a new approach to the management of personnel programs in the Federal Government. In 1978 an occupational survey of the GS-1102 and 1105 series was administered to some 20,000 Federal civilian and military employees. The results of that survey were analyzed using an established occupational analysis methodology. One phase of the analysis determined the functional (job-performance based) specializations in these two occupational series. This analysis identified six major functional areas. Within each of these areas, 54 job types were identified. In two areas, job types were identified. In two areas, Contract Generalist and Staff, job types were organized by families of related jobs within the area. This analysis points out the implications of this type of information for personnel management and how it can support functional managers for the best utilization of their employee resources.

In 1977 the Federal Acquisition Institute (FAI) began planning what was to become the first occupational survey of Federal civilian employees in history, and the largest of it's type. This survey was to define the task performance of a representative sample of three acquisition occupations: GS-1102, Contracting and Procurement; GS-1105, Purchasing; and, GS-1150, Industrial Specialist. The reasons for this massive effort were to define the tasks performed by personnel in the total grade range of these series, identify the demographic characteristics of the three areas, and define the functional specializations of the areas, excluding GS-1150. Having this information, especially task-level information, it would be possible to develop or evaluate training courses or programs, individual development plans or agency-wide career development programs, performance appraisal systems, or any number of other personnel management tools.

To gather such information in a systematic and efficient manner, the FAI used a time-tested, operational methodology, the task inventory. This methodology was developed in the early 1960's by the Air Force System Command's Human Resources Laboratories (HRL). After the test and development phases of this project, and the utility and value of the process was realized, the Air Force created what is now known as the USAF Occupational Measurement Center (OMC). Since 1966 OMC has been developing and analyzing occupations using this process, and with HRL, strengthening the methods and software. A testament to their success has been the utilization by other US and foreign armed services of similar program offices. In view of their experience, the FAI arranged for OMC to develop a survey instrument, and the HRL to provide the computer support for this study.

A randomly selected sample (60%) of GS-1102, 1105, and 1150 employees and military counterparts was used for the survey population. Based on projections from agencies, a 60% sample of personnel in other series (such as GS-301, 801, 2000,) but spending at least 50% of their job time in contracting, procurement or purchasing, was surveyed. Based on these samples, 21,610 survey booklets were delivered to the agencies for administration. The time allotted for respondents to fill out the questionnaire was 4 hours; most respondents (based on telephone conversations with a sampling of administrators) were finished within 3 hours. After 15 weeks 65% of the booklets had been returned, and returns had virtually stopped, so the survey was closed out and analysis began. Agency response rates varied, from a high of 85% for one agency to a low of 22% for another. However, looking at the relative proportion of respondents' grade levels in the 1102 and 1105 sample of the official OPM population statistics, we are confident that we have a representative sample.

The Survey Booklet. The survey booklet contained 3 parts. The first part contained the instructions and Privacy Act statement. This allowed self-administration. The second part was a background information section which asked a number of questions related to the respondent and his position. This information was asked for so that analyses could be made on the basis of questions such as "What does a NASA, GS-1102, grade 9 do?", and to help explain why some positions are very similar. The third section of the booklet was the task listing. In this section, 1,480 tasks were listed alphabetically. Respondents were asked to read the tasks and mark the ones they perform. They were then in-

structed to rate the tasks they perform on a relative-time spent scale (1=low, 9=high). Task responses of each individual became a "job description" for their position. These job descriptions could then be compared or combined easily by the computer for the analysis of the occupations.

FUNCTIONAL SPECIALIZATION

For the purposes of this paper, only the findings of the job type analysis of the data will be discussed. (1). To simplify the computer program's workings, each individual's responses is compared to every other individual's. The most similar pair are combined and the process repeated. This comparison and combination process continues until the last two groups are combined into the single group of the whole. (Background information is not a factor in the determination of this grouping process.) In this case, the group of the whole was a stratified random sample of 6,982 respondents in the GS-1102 and 1105 series as well as respondents in other series who spent more than 50% of their job time on the tasks they marked in the booklet.

The analysis revealed 54 identifiable job types in this sample. These 54 job types were organized into 6 functional areas: Purchase Order Writers (2 job types); Small Purchases (4 job types); Contract Generalist (18 job types); Contract Administration (11 job types); Cost-Price Analysis (4 job types); and, Staff (15 job types). The Contract Generalist Function was composed of 2 sub-areas, Contract Award and Contract Management. The Staff area also had an extra layer of organization. Three families (intermediate levels of organization) of jobs were found: Review, Line Management, and Policy and Regulation.

The various functional areas were characterized by bodies of tasks which were common to each area. (Since there was a finite set of tasks in terms of time spent on some tasks being different for various groups.) While space does not permit an exposition of the tasks for each of these areas, examples and characterizations will be given.

Purchase Order Writer. The members of this group performed a very small number of tasks on average (38). Nearly all their tasks were directly related to preparing or following-up on purchase orders. The 2 job types, Entry and Specialist, had average grades of 5.9 and 7.3 respectively. Forty-four percent (44%) of the members had at least a Bachelor's degree.

Small Purchasers. On average, the members of this group performed 132 tasks. The most time consuming tasks dealt with small purchases. Nearly ninety percent (89.2%) had less than a Bachelor's degree. While some of the tasks illustrated here can apply to forms of procurement other than small purchases, their meaning in this context is small purchase related. Some common tasks of the area: Analyze market practices for commodities or services; Conduct oral solicitations; Coordinate delivery order requirements with mandatory sources of supply, such as CSA; Maintain files of purchase or delivery orders and modifications; Perform follow-ups on small purchases; Prepare priced purchase orders. Members of the group called themselves "Buyer" and "Purchasing Agent" or similar titles. Twenty-seven percent (27%) of the group were CS-1102's. As a group, the 1102's had higher grades than the 1105's in the same job types. The job types found (average grade in parentheses): Small Purchase Technician (6.3); Small Purchase Award Specialist (6.2); Small Purchase Award & Administration (6.9); and, Central Small Purchasers (6.2).

Contract Generalist. This functional area was the largest, by far, 46% of the sample. The average number of tasks performed by the group members was 216. Of the Contract Generalist area, the Contract Award sub-area contained 70% of the members, Contract Management 30%. The Award sub-area jobs tended to have lower grades than the Management sub-area (ranges 8.6-12.1 and 10.4-13.3 respectively). Further, the Management sub-area tended to have tasks and demographic data which were characterized by signatory authority, post-award responsibility, and supervisory responsibility. Fifty percent (50%) of the members had at least a Bachelor's degree. Award sub-area job types found (average grade): Commodity Specialist - Advanced (9.6); Construction-Award and Administration (9.5); Central Procurement Specialists (10.6); Central Procurement Contracting Officers-Award (12.1); Major Systems, Research & Development Contract Negotiators (11.2); ADP Procurers (11.1); Research & Development Contracting Specialist (11.1); Central Contracting-Real Property (10.0); Major Systems, Research & Development Negotiation Team Members (11.0); Construction Specialist-Award (8.6); and, Commodity Specialist (8.6). Management sub-area job types (average grade): Central Procurement Contracting Officer-Award & Administration (12.0); Installation Contracting Officer (10.4); Research & Development Contracting Officer (13.3); Major Systems Contracting Officer (13.2); Managerial Contracting Officer (12.5); Construction Contracting Officer (10.9); and, Supervisory Contracting Officer (12.3).

Contract Administration. This area was characterized by pre-eminent time requirements of post-award and, in cases, terminations and claims tasks. The group's average task performance was 140 tasks. Just less than half (49%) of the members had Bachelor degrees or more. The average grades of the job types ranged from 8.9 to 12.3. The job types found were (average grade): Contract/Administrator/Negotiator (11.0); Termination, Close Out and Claims Administrator (11.6); Administrative Contracting Officer (11.9); Contract Administration Assistant (9.7); Contract Administrator I (9.5); Supervisory Contract Administrator (11.2); Construction Contract Administrator (9.1); Contract Administrator II (8.9); Contract Terminator (12.3); Engineering Contract Administrator (11.7); and, Industrial-Production Engineering Contract Administrator (11.6).

Cost-Price Analysis. Expectedly, the major portion of this group's time was spent on tasks related to the analysis of costs and prices in support of the acquisition process. The members of the function performed an average of 74 tasks. At the GS-13 level, for the group as a whole, it was noticed that the members become actively engaged in negotiations. As a group, this was one of the more educated, highest in terms of Bachelor's degrees and second in terms of members with post-graduate work or degrees (68% had a Bachelor degree or more). The job types within the area ranged in average grade from 10.5 to 12.5. The job types identified: Cost-Price Analyst-Advanced (11.5); Cost-Price Analyst-Basic (10.9); Overhead Agreement Cost Analyst (12.5); and, Cost-Price Analyst/Negotiator (10.5).

Staff. The Staff area was composed of three families of jobs: Review, Line Management, and Policy and Regulation. Overall the average grade for the area was 12.3. For the sub-areas the grades ranged from 10.5 to 12.5 for Review, 11.6 to 13.1 for Line Management, and 11.9 to 13.2 for Policy and Regulation. Of the Staff area, 57% had a Bachelor's degree or more (29% had post-graduate work or degrees). Job types in the review sub-area: Contract Reviewer (12.2); Senior Contract Reviewer (13.10; Procurement Liaison (12.0); Staff Sub-Contracting Specialists (11.6); Small Business Officer (12.4). Found in the Line Management area were: Branch/Division Supervisors (11.9); Contract Administration Branch Chiefs (13.2); Contracting and Procurement Managers (13.7) Policy Review and Inspection (13.3); Small Purchase Branch Supervisors (10.1); and Supervisory Contracting Officer (12.5). The job types identified in the Policy and Regulation sub-area: Policy Review Analyst (13.2); Policy and Regulation Writer (12.9); Business Advisor/Liaison (12.9); Information Systems Specialist (11.9) (a procurement management support function). The average number of tasks performed by Staff members was 86 tasks.

Job type titles were given on the basis of trying to describe the unique nature of the important tasks for the group, in relation to the other job types in the functional area. A good deal of insight was gained through the responses to a background question which asked for the person to write a title for his position which he or she felt best described their duties and responsibilities.

UTILITY OF THE DATA

Job type analysis groups individuals by the tasks (job behaviors) they perform, not by the grade, title, series, or other demographic factor of the person or position. The jobs may differ on the individual tasks performed, or the relative time spent on a similar body of tasks. Despite how the job groupings were formed, the results are applicable to a number of management tools. For instance, an agency may choose between developing a training program for a particular type of job (job type), "Contract Administration Assistant" for example, or decide to plan training for a function (Contract Administration, for example). Data can be presented for the consecutive grade-levels within the function, or the best approximations to the grade levels in terms of job types. In each case the data elements are basically the same (i.e. tasks, percent performing, percent time spent), but the ordering and range of tasks may change. The data are there to support management's needs. In some cases the data may suggest the direction that management should investigate.

Agency managers can also compare how their personnel grouped to those of other agencies. How does utilization differ from agency to agency? Is there something to consider in these differences? One often overlooked aspect of task data is the non-performance of tasks and the effect of this. Are there significant tasks that are not being performed, or have the probability of performance as one would imagine?

When looking at the data, are there tasks which appear to be too time consuming? If a way could be found to aid the performer in doing these tasks, couldn't more work be accomplished, or done faster, or more efficiently, or with fewer mistakes? Research in this area could save a lot of time and money.

Training dollars are limited, but your training requirements are not. How do you get the most effective result for your investment? You prescribe to the training specialists the outcomes you want from the course in terms of tasks. You have the data that show how likely and how time consuming the tasks are for the positions. By setting concrete behavioral outcomes for the trainers, you help them prepare the product they want, a course (formal or OJT) that meets your needs. Perhaps you already have a training program; how well does it meet the needs of the people for which it is designed? With job analysis information you can compare the training content and emphasis to the content and emphasis of the job.

Rather than training, if career development were considered, a similar framework would develop. General agency-wide programs within and across the functional areas could be charted with specific behavioral goals. Employees would have a specific knowledge of what was expected of them, what was expected of their assignments, and how other areas relate to the work they perform. Carreer paths can be expressed in concrete terms, both within and across functional areas.

A performance appraisal system should recognize the differences as well as the similarities of the tasks performed by personnel in the procurement field. The job analysis has shown that while there are some tasks similar in importance and performance for the field as a whole, differences between the fields are striking. For each area we know the relative ranking of tasks and the differences in rankings between areas. Any measurement of performance should consider this

information and evaluate it in terms of it's criticality in the appraisal of performance.

The Uniform Guidelines on Employee Selection Procedures (2) states the need for a thorough job analysis for the validation of employee selection instruments. The type of job analysis applied to the data in this study should meet the criteria prescribed by the guidelines. This data is not easy to come by, it requires a lot of time, money, and effort; but it is a sound investment. Depending on the needs of the user, the data may need further analysis, or follow-on studies. The important fact remains, the foundation has been laid, we can more easily determine what we can or need to do next.

This information will prove to be of greater use in the future. The data we have now is a baseline. When we survey the occupations next, we will be able to identify trends, measure impact of procurement and personnel policy changes, and hopefully anticipate changes that are in process of evolving. If, as a result of this analysis problem areas have been identified, we will be able to ascertain the extent to which they have been cured, and if new problems have arisen.

This information, in conjunction with our planned personnel system, will allow us to forecast needs in terms of personnel replacement, recruiting, and selection.

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TRAINING IN THE 80's

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ABSTRACT

The paper presents a review of some of the source literature undergirding four trends of the direction of training to meet the increasing, yet differentiated, training demand of the 1980's. The four trends are: (1) The shifting from the knowledge and skill transmission model toward a competency development model, (2) the growing body of knowledge regarding needs, styles and processes of adult learning, (3) the requirement to provide a more diversified and flexible delivery system for training, and (4) a larger component of the role of the managers being concerned with development of their subordinates. The paper concludes with the challenge of calling for specific actions to exploit the benefits of these trends.

During the 1980's there continues to be a demand for training of those working in Government procurement and contract. More importantly, that demand will increase significantly and will be differentiated from that of the 1970's. This differentiation will be brought about partly by the expected turnover of personnel. However most of that increase in demand will be due to changes (agency mission changes, policy changes, management and business practice changes, and changes to the concern of application of skill to the specific market and technology of the systems, supplies and services procured by the Government.

The training to be supplied in the 1980's to meet this increasing and differentiated demand will be directed in ways other than that traditionally done in the 1970's. These directions are taking shape as indicated by four trends:

1. There is a continued shift away from the knowledge and skill-transmission model as borrowed from traditional schooling toward a competency-development model.

2. There is the growing body of knowledge accumulating regarding the needs, styles and processes of adult learning.

3. A much more diversified and flexible delivery system for our training programs is required.

4. Managers and supervisors seem to be coming to see a larger and larger component of their roles as being concerned with the development, not just the control, of their workers. (1)

This paper presents a review of some of the literature undergirding these trends. For the most part, the orientation of the review is that of the individual who will be participating in the training.

From a practical viewpoint, the information should be useful to those who are concerned with professional development of procurement practitioners. This includes not only members of the career boards of the Federal agencies, but also 1) those executives, managers, supervisors involved in procurement operations within Government agencies, and 2) the administrators, department heads, teachers, writers and librarians of the various schools and training organizations, both Government and proprietary.

SHIFT TO COMPETENCY DEVELOPMENT MODEL

The public is concerned about the integrity of the processes through which the Federal procurement expenditure is made. The critical component in the processes concerns the competency of the application of the knowledge and skills possessed by personnel working in the procurement offices. (2)

Procurement training programs have been specifically established for civilian personnel by some Federal agencies. Part of these programs provided for specific job oriented courses to be taken during the procurement practitioners' progress from Grade GS-5 to Grade GS-13. (3) Some of these courses are stipulated as "mandatory" because of the need within the agencies of training programs which sufficiently assure a minimum level of competence of its procurement practitioners. (4) Part of this need arises from the diversity of educational backgrounds and job experiences of these people. (5)

It has been found that the major learning is on the practical rather than the academic, the

applied rather than the theoretical; and on skills rather than knowledge or values,(6) and subject matter directly useful to the performance of everyday tasks and obligations represented a significant segment of the total activities.(7) Concerning skills used by administrators, Katz identifies three different skills: 1) technical which deals with functions, 2) human which is concerned with people, and 3) conceptual is with ideas.(8) Skill is defined by Katz as translating knowledge to actions; hence, competence. Therefore training projects are concerned with subject matter related to a person's job or occupation, not only with the skills at the entry level, but also maintaining new knowledge and skill, and preparing for promotion.

The individual sets out to gain a certain knowledge and skill because it will be highly useful in the very near future.(9) His time perspective is one of immediate application.(10) The individual, as an adult, is not only ready to learn different things because he faces different developmental tasks, but also is interested in the immediate usefulness of the new knowledge.(11) Some anticipated use of an application of the knowledge and skill is the strongest motivation for the majority of learning in training(12) One of the crucial characteristics for competency of a professional is knowledge oriented in that the individual 1) have the qualities of a specialist, 2) excel in the manipulation of the tools and techniques of his profession, 3) master a body of knowledge related to his profession, and 4) to be effective in his profession, have a definite and practical object.(13) Competent professional practice presumes at least a general understanding of related disciplines, especially in the behavior and social science. In other words, the preparation of the many practicing professions must be eclectic.(14)

Merely increasing knowledge and skill does not assure the increased ability to perform. Consequently training programs must include competency development in their planning, design and competent performance by procurement personnel. The public demands competent performance by procurement personnel.

GROWTH IN ADULT LEARNING THEORY

Much of the theory about learning is not based upon experience with working adults,(15) and some of the immutable truths about learning are suddenly being questioned seriously,(16) especially where adults are concerned.

The positions which are currently adhered to among learning theorists can be grouped into the following three principal orientations. The first, behaviorism, is concerned with the observables of behavior, namely stimuli and responses. Strict behavioristic doctrine avoids any speculation about what is going on in the mind. The second, neo-behaviorism, also considers stimuli and responses as the only valid indicators of behavior but they also consider what happens between the input of stimuli and the output of responses in terms of mediational processes. The third, cognitivism, deals with man as a rule-forming being and the cognitive structure of the individual is consider-to be of paramount importance for learning.(17)

Dubin and Okun developed a taxonomy of the learning theories. As presented in Table 1, it points out the relevancy of each theory for adult instruction. It shows the descriptive comparison of learning theories in terms of orientation, central concept, the role of the instructor, amount of structure associated with model, and appropriate conceptual level. The amount of structure refers to the extent to which the process of instruction is controlled by the instructor. The conceptual level represents an attempt to match the personality development of the student with an appropriately structured environment. The blank spaces occur because the learning theorists did not attempt to relate his model to the instructional processes.(18)

While Table 1 presents a comparison for instructional purposes, one observes an inverse relationship of the variables in the last two columns--"Amount of Structure" and "Appropriate Conceptual Level." This inverse relationship reveals the alternative types of learning with which one is interested. The high amount of structure and low conceptual level indicate some agreement as well as differences among the three theoretical categories.

It appears that the highly structured models of the three categories in the taxonomy operate at the lower levels of the scales for these two variables while the remaining two of the cognitive models operate at the higher levels of the scales. Rogers' nondirective teaching technique is appro-

TABLE 1

A TAXONOMY OF LEARNING MODELS

Learning Theory	Name of Model	Exponent	Key Concepts	Role of Instructor	Amount of Structure	Appropriate Conceptual Level
Behaviorist	Operant Conditioning	B. F. Skinner	Reinforcement Shaping	Behavior Modifier	High	Low
Neo-Behaviorist	Drive Reduction	Clark Hull	Habit-Family Hierarchy			
Neo-Behaviorist	Neuro-Physiological	Donald Hebb	Cell Assemblies and Phase Sequences Mediation	Source		
Neo-Behaviorist	Social Learning	Albert Bandura	Imitation Vicarious Learning Symbolic Models	Model and Prompter	High	Low
Neo-Behaviorist	Learning Systems	Robert Gagne	Task Analysis Hierarchical Categories of Learning	Manager of Conditions Learning	High	Low
Cognitivist	Discovery Learning	Jerome Bruner	Categorization Coding Systems	Prompter	Moderate	Moderate
Cognitivist	Reception Learning	David Ausubel	Advance Organizers Subsumers Cognitive Structure	Disseminator of Information	High	Low
Humanist	Nondirective Teaching	Carl Rogers	Self-Actualization Phenomenological Field	Facilitator of knowledge	Low	High

SOURCE: Samuel S. Dubin and Morris Okun, "Implications of Learning Theories for Adult Instruction," Adult Education, XXIV, 1, 1973, p. 11.

priate for individuals who are clearly operating at a high conceptual level,(19) especially for self-directed inquiry.(20) It is concluded that this kind of distinction suggests that different theories of learning and teaching might be appropriate for different kinds of learning.(21) This suggests a continuum beginning with "Training" at one pole, continuing through "teaching" to "self-directed inquiry" at the other pole.

DIVERSIFYING TRAINING DELIVERY SYSTEMS

There is substantial evidence that most management, technical, and craft skills are developed on the job more effectively than in formal education institutions.(22) Concerning entry to a new job or occupation, an individual may have to take many training courses or learn in other ways.(23)

Reports are periodically made showing the number of personnel within the specific procurement occupations that have completed the mandatory courses required for their grade or rank. A typical report may reveal that less than 50 percent of the civilian procurement personnel have taken the mandatory courses. One reason for this is the lack of available spaces at the training locations. Acquiring the knowledge and skill must have been accomplished by other means.

Because of budgetary constraints, education and training currently faces a financial crisis. Alternative strategies are called for. One alternative is the use of independent study.(24) The Office of Personnel Management is encouraging more active programs of occupation-oriented self-education and training throughout the Government. (25) The Federal Personnel Manual stipulates that ". . . the head of each agency is responsible for encouraging the self-education, self-improvement, and self-training of the employees of the agency. (26) The Government Employees Training Act, P.L. 85-507 as codified in Title 5 of the United States Code, Chapter 41, recognizes that it is ". . . necessary and desirable that employees' self-education, self-improvement, and self-training be supplemented by Government-sponsored programs."(27)

The management philosophy of an organization is an influence on adult learning training delivery and instruction. It has been observed that "theory X management philosophy and the mechanistic (behavioristic) learning-teaching models are remarkably similar, as are those underlying Theory Y management philosophy and the cognitive learning-teaching models."(28)

The procurement workers and trainees expect to learn and the better educated approach the situation with a strategy in mind.(29) They have a preference for certain ways of learning, which is determined by past experiences (successful or negative) and the reaction of acquaintances. The most important criterion for selection is efficiency with respect to the characteristics of the subject matter, how the person learns best, and what is available in terms of content and the costs of both time and money.(30) Certain strategies or methods are more effective in increasing knowledge and competencies than are other methods.(31) The types of training strategies, schemes, or methods are self-planned, group, person, media or a combination of these.(32) By a self-planned program is meant the degree to which each individual developes and maintains a plan or program for his own development, or at least some control over his own immediate environment.(33) Houle points out that the inner reality lies in the service of authority and direction so far as planning and control are concerned.(34) These reasons are why the person wants to retain the primary responsibility himself range from the uniqueness of the knowledge and skill to the satisfaction derived from self-planned learning.(35) Steps involved are 1) establishing a learning agenda, 2) planning a strategy, and 3) evaluating the chances for success.(36) An individual can use his own learning agenda which is designed to fit his own style of learning,(37) which takes place in a variety of ways--an inherent part of a person's pattern of life, beginning with a central component of a learning design and adding to it systematically, or haphazardly simply because of new material or the flexibility permitted.(38)

In the group learning strategy, the instructor, or the leader in a group plans the learning activity. The leader of the group makes most of the decisions about what and how he should learn during each learning episode.(39) There are a variety of formats ranging from a group with an instructor to an unstructured conference or autonomous group. (40) Besides being a highly efficient route to learning, the group method is attractive for many reasons, such as group members assisting each other and having access to an instructor.(41) However, this method has its negative characteristics, as well, which range from fear of showing ignorance to not being able to find a group at the appropriate time.(42) Among practitioners in certain occupations and professions, the educational activities which ranked the highest included participation in workshops, institutes and professional associations.(43) Meigs and Gottlieb reported that the respondents to their survey (those involved with Government contracts) claimed frequency of attendance at conferences, seminars, and courses ranging from 2 percent for weekly attendance to nearly 40 percent for annual attendance at such activities.(44)

Many persons rely on peers for learning new practices.(45) Learning can proceed very effectively when guided by the appropriate person interacting with the learner in a one to one situation.(46) That appropriate person--whether a peer, superior, friend or expert--may be more competent than the trainee if he has already performed successfully in the occupation and knows just what knowledge and skills are necessary.(47) In some dyadic relationships, the person either demonstrates the skill or presents orally the knowledge to the learner, whereas in other projects, the person recommends readings, exercises, forms of practice or other activities to the learner.(48) The trainee in some dyadic relationships can influence the

objectives, content, and activities, while other learners in other dyads may feel compelled to follow the directions of the person, especially if that person is considered a master.(49) Advantages of the dyadic strategy include having the expertise of the person adopted to the learner and providing immediate responses to questions of the learner.(50) However, this strategy is not as commonly used as is self-planned or group-planned projects.(51)

There have been quantum leaps in programming theory and practice. That even more rapid progress will be made in the eighties is clear. The communications explosion and boom in educational technology, have placed new demands upon the trainer. We may expect new opportunities for self-directed as well as group learning.(52) With programmed learning, television and radio and improved correspondence study programs integrated into other learning activities, independent study or self-learning may expand greatly.(53) Programmed instruction and computer assisted instruction are sometimes called individualized instruction because they let the trainee proceed at his own pace.(54) Highly sophisticated simulations and printed simulation materials provide additional opportunities for learning that are far more effective than reading.(55) Other media type materials or nonhuman planned learning include film strips, tape recordings, television programs, etc.(56).

MANAGERS AS DEVELOPERS

Occupations differ from one another in the amount and kinds of further education they require of practitioners.(57) Moreover, the diversity of organizational situations in which practitioners of specific occupations find themselves differing from one another in amount and kinds of preparation required periodically for effective role performance.(58)

For those working in the dynamic knowledge work occupations or the professions, an updating model has been proposed to combat obsolescence--a threat to such practitioners' competence. One factor in this model is organizational climate which can be thought of as a multi-dimensional factor, comprised of five components: organizational practices, supervisory behavior, on-the-job problem solving, colleague interactions, and management philosophy.(59).

The world is too complex and is changing too rapidly for any person ever to master all he needs to know for future working and living. The demand for special competencies, for new skills unanticipated when an individual began to practice his profession, and for increasingly specialized practice, have inspired the literary in support of schooling through university and continuing beyond until the end of an individual's work life. The tasks of middle age involve substantial changes and require considerable learning (as one) reaches the peak of one's work career.(60).

One general response to the problem of worker competence raised in modern times is the massive investment in education and retraining.(61) There is a need for organizations to express their concern for technical obsolescence in tangible ways--in ways which provide opportunities for individuals to plan and execute their development activities.(62) With the swiftness of evolution in social and technical affairs, it is clear that individuals are affected and have good reason to be concerned with technological change.(63)

The highest expression of the act of the manager/facilitors is skill in helping subordinates to discover and become interested in their own needs.(64). Several types of persons provide assistance, such as fellow workers, intimates, acquaintenances, experts, paid professionals, etc.(65) It has been found that management in an organization cannot trust the individual to make the self-selection decision alone.(66)

Because there were many who had started efforts but never finished, it has been concluded that the strength of the individual's motivation state may not be sufficient to carry out a program of self-instruction.(67). A study of seventy managers revealed that very few had any clear aims or learning goals since they lacked skill and practice in formulating learning goals and did not have access tc a trained learning consultant.(68). Another study found that all participants are goal oriented even though in some the goal is subtle and difficult to detect.(69).

It has been found that surprisingly little help is available for the working adult when he is deciding . . . whether to proceed, since appropriate decisions lead to successful projects and poor decisions may lead to failure or quitting. (70). The requirement that the person take some responsibility and initiative in planning out and carrying out a portion of their learning is for many learners a severe requirement in itself.(71). A person may experience some difficulty or doubt when deciding whether to begin or continue learning.(72). Perhaps many lack competence in diagnosing their own learning needs and in helping others do the same and could benefit from appropriate help in this case.(73). In many projects the person requires no help, while in others, a friend, expert, supervisor, or counselor aids the person in the decision.(74).

The reasons why any subordinate may seek assistance is that 1) he may not know which books and people can provide information, 2) he may not know what activities are necessary for learning new knowledge and skill, and 3) he may need encouragement and emotional support.(75). Many things can go wrong during the person's attempts to get help. He may encounter difficulties and frustrations at any point in his efforts to obtain help, and these problems may effect his feelings and efficiency.(76). He may be 1) unaware of needing help, 2) uncertain about which steps need help, 3) uncertain how or where to get

help, 4) not taking action, 5) unable to reach resource, 6) having difficulties making contact with resource, and 7) incurring excessive cost in terms of time and money.(77). Peter Drucker advocates that "we must develop the ability and motivation to keep on learning to place emphasis in our approach to the continuing excitement of coming to grips with what is unknown, rather than a commonplace acceptance of what is already known.(78).

THE CHALLENGE

Increased knowledge or skill does not automatically assure increased ability to perform especially in complex operations. The concept and theory of competency development need to incorporate this system of thought into our philosophy of training. Mastery of the techniques of constructing competency models for the various roles to help people learn to perform is demanded. More rigorous observational, interviewing, direct assessment, and heuristic techniques need to be employed. Constructing and using criterion-referenced diagnostic instruments and performance-assessment instruments is required. Competency - development learning resources are beginning to appear on the scene.

Regarding the needs, styles and processes of adult learning, more has been done in the last decade about the stages of development (and, therefore, points of readiness to learn) during the adult years than in all previous history. . . and the volume is accelerating. Adults have a deep psychological need to be self-directing in their learning. The role of trainer should be reconceptualized away from that of prescriber, transmitter and evaluator of learning toward that of facilitator and resource for self-directed learners.

With respect to the diversified and flexible delivery system for our training programs, there is the demand for making learning opportunities available to employees at times, in places, and at paces convenient for them and their managers. Highly individualized learning-by-doing, work - based learning experiences also must be packaged and made available. New ways must be learned to relate internal learning resources to those of the surrounding community so as to make the resources of the entire community available to employees in more functional ways.

The role of training is shifting from one of primary managing the logistics of training activities to one of consulting (and helping) line managers in performing an educative role. The quality of human growth and development that takes place in a corporation or agency is a function of the educative quality of the total environment of the workplace. The role of training is becoming essentially one of environmental engineering.

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A SOLUTION FOR COGP RECOMMENDATIONS
A-12, 13, and 14, regarding
THE CONTRACTING OFFICER

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ABSTRACT

The role of the U.S. Government's Contracting Officer is critical to effective expenditure of public funds. He must accomplish, in a way satisfactory to the public, the expenditure of hundreds of millions of dollars each year by almost 20 million purchases. Everyone has a stake in this activity. We must be sure that a business conscience of the Federal Government exists and resides in its contracting officers. Who they are, and the development of their capability is a critical matter for all.

This examination includes a qualitative analysis of demographic data about contracting officers and recent information as to the actual organizational level in Government where contracting officers are found.

Current steps underway to reinforce regulatory material to require extended competence of contracting officers are pursued.

Part I - Background: The judicial expressions in "case law", studies by reknowned groups like the Hoover Commission and the COGP and others, and the regulations of various Government agencies, have provided a "blue Print" for what the contracting officer should be. It is a very special person that is so described, and the responsibility and demands for action require that we attend to the qualifications and authority of such persons.

What is it that this historical plethora of studies conclude? First, two U.S. Supreme Court cases:

In 1876, the court distinguished the special character of the contracting officer in 93US247, saying:

> "... Different rules prevail in respect to the acts and declarations of public agents from those which ordinarily govern in the case of mere private agents. Principals in the latter category are in many cases bound by the acts and declarations of their agents even where the act of declaration was done or made without any authority, if it appear that the act was done or declaration was made by the agent in the course of his regular employment; but the government or public authority is not bound in such a case, unless it manifestly appears that the agent was acting within the scope of his authority, or that he had been held out as having authority to do the act, or was employed in his capacity as a public agent to do the act or make the declaration for the Government".

In 1910, the court commented on the contracting officer as it had come to be, in 217US286, as follows:

> "Because of the peculiar position of the Government contracting officer, with the great power he is able to exercise, it is necessary that he act with honor, integrity, and the highest good faith in the performance of his contractual duties. In the nature of things this is somewhat utopian, so that the rule is that the finality of his decision is reviewable administratively when the contract so provides, and judicially when the decision is arbitrary, capricious, fraudulent, or not supported by substantial evidence. The contracting officer's relationship to the Government is that of a fiduciary. If he breaches his trust by participating in the profits from a contract he let, for example, he becomes a trustee ex maelficio, and the Government can recover those profits from him."

Contracting officers are also required to act independently after fair consideration of the facts in question. McBride and Wachtel, "Government Contracts," 5.80, synopsized these cases as:

> "The contracting officer's decision on a question of fact must be personal and independent, Climatic Rainwear Co. v. United States, 115 Ct. Ct. Cl. 520; 88 f.Supp. 415 (1950). If he is directed by a superior officer to decide the dispute in a certain way without regard to the evidence before him, his decision is a nullity and it cannot be sustained, Johnson Contracting Co. v. United States, 132 Ct. Cl. 645, 132 F. Supp. 698 (1955). Consequently when the contracting officer terminated the con-

tract for default without any consideration of the merits of the case, and that termination was dictated by a subcommittee of Congress and by the contracting officer's superiors, the decision was a nullity because the contracting officer was not permitted to exercise his discretion as required by the contract. Schlesinger v. United States, 182 Ct. Cl. 571, 390 F.2d 702 (1968). In the case last cited, the discretion questioned was not that of the contracting officer but of the Department of the Navy in surrendering its power of choice. The difference between the disputes clause and the default clause should be noted. The disputes clause requires a decision of the contracting officer. The default clause requires a decision of the Government.

In summation, the United States in using its Contracting Officer agents to enter and manage contracts, makes severe demands on those people so chosen!

The most wide-ranging analysis of the contracting officer issue was reported by the COGP in 1972. The pertinent items follow:

"PLACE OF PROCUREMENT IN AGENCY ORGANIZATIONS

Recommendation 12. Reevaluate the place of procurement in each agency whose program goals require substantial reliance on procurement. Under the general oversight of the Office of Federal Procurement Policy, each agency should ensure that the business aspects of procurement and the multiple national objectives to be incorporated in procurement actions receive appropriate consideration at all levels in the organization.

ROLE OF THE CONTRACTING OFFICER

Recommendation 13. Clarify the role of the contracting officer as the focal point for making or obtaining a final decision on a procurement. Allow the contracting officer wide latitude for the exercise of business judgment in representing the Government's interest.

Recommendation 14. Clarify the methods by which authority to make contracts and commit the Government is delegated to assure that such authority is exercised by qualified individuals and is clearly understood by those within the agencies and by the agencies' suppliers of goods and services."

One of the best restatements of the foregoing material, presented here as a summary for this Part I, is from the ICAF text on procurement. They say:

"It takes people to make organizations, laws, and regulations effective, and herein lies the key to the efficiency of defense procurement and to the proper safeguarding of the Government's interests in its vast expenditures for the purpose. The secretaries of the military departments and the director of DSA are empowered to delegate the basic responsibility vested in them by the Congress to execute and administer contracts. This is the job of the contracting officer. In large and complex operations, different officers may be designated for the award, administration, termination, and settlement of contracts. Within the Defense establishment contracting officers may be either military or civilian.

In many respects the contracting officer is limited agent. His authority to bind the United States is restricted to the limitations of his appointment, the directives of his department, the regulations of ASPR, the Federal statutes, interpretative decisions and opinions and, in the final analysis, the Constitution. These limitations apply in all contractual actions to which the United States is a party, notwithstanding the fact that a contracting officer may have exceeded them. It is, therefore, incumbent upon the private parties contracting with the Government to be aware of a contracting officer's actual authority.

The consequences of a contracting officer's actions underscore the importance of selecting highly qualified persons for that job. Contracting officers, therefore, must be chosen only after examination of their experience, training, judgment, maturity, character, reputation, ethics, and their understanding of the laws and regulations governing military procurement. Furthermore, the authority granted a contracting officer should be commensurate with the specific need and capability of the activity they represent. To improve standards and assure uniformity throughout the Services, the Armed Services Procurement Regulation sets forth the factors to be considered in the selection and appointment of contracting officers and requires documented support for each appointment."

<u>Part II - What Do We Have Now</u>? In their "final" report on COGP recommendation implementation, the GAO said in Report To The Congress, No. PASD 79-80, May 1979, that:

> "Currently, employees awarding contracts need not meet minimum qualification standards by regulation or law. Nor are they required to take training or attain a certain level of education or experience. One method to achieve professionalism would be to quality contracting officers who meet minimum standards of competency. The new draft FAR (part 1.603) contains the policy for selection of contracting officers. The regulation illustrates desired attributes, but does not lay down or require qualifications standards for contracting officer appointments."

In September 1979, the FAI published "Federal Contracting and Procurement Workforce Demographics." Some of their "highlights" were:

- An individual's pay grade is related to his educational attainment. Among 1102 - Contract

and Procurement employees, 36% of the GS-11's have graduated from college while 68% of the GS-14's have done so. An even greater difference is found among 1101 - General Business and Industry employees where the respective percentages are 25 and 67.

- The educational level of employees within the same occupational series differ by geographic location. Sixty percent of the 1102 - Contract and Procurement series working in Dayton, Ohio, have graduated from college while only 38% in the St. Louis area have done so.

- Among 1102 - Contract and Procurement employees The Small Business Administration, NASA, Department of Transportation, and Other Defense (i.e. Defense Logistics Agency) have the largest percentage of employees who are eligible for some form of retirement.

- Among 1102 - Contract and Procurement employees there are twice as many college graduates between the ages 20 and 34 than there are among employees over 45.

- Among 1102 - Contract and Procurement employees the distribution of grades is quite similar for age groups 35-39 above. Thus, it appears that there is not a strong relationship between grade and age.

Further analysis of the same data bank, tuned to the issues of contracting officer authority, provide some additional findings:

- Nearly half (45.7%) of the people who can obligate the U.S. in transactions with a value of more than $10M have no college degree.

- For salary levels between GS-9 and GS-15, the capacity to obligate the U.S. to transactions greater than $10M is not related to educational levels.

Assuming the same intake ratios as now and uniform promotions with time we can see a pulse of better educated entry and journeyman moving into the higher grades and into the levels of greater obligatory authority. The impact of FAI and other's initiative in the colleges and universities should begin to be felt. The underlying assumption is that a better educated 1102 workforce is in the long term best interest of the Government.

What conclusions can be reached from the foregoing material? We believe the current workforce does not satisfy the demands defined in Part I. While education is not per se sure to satisfy such demands it is almost universally believed that more education gives better judgements and perhaps greater levels of other attributes.

FAI has, in the past year, collected more information on organizational placement: it is reported here for the first time. Seventeen agencies were surveyed with almost 500 procurement offices responding. In 13 agencies the most senior procurement person was two or more levels below the head of the agency. Other data showed that generally the procurement function was one to two levels below the program/technical senior level. Further the GS grade level was 1 to 3 grades lower than program/technical persons. Another line of inquiry related specifically to the Contracting Officer: In all the civil agencies (i.e. all less DoD) many positions, even those filled by non-procurement persons, give authority to the incumbent as contracting officer. Many such positions were found not in the procurement line of authority, i.e. they did not manage or participate in the agency's "mainstream" procurement organization.

It should be noted that a variety of agencies are now (early 1980) preparing qualification and/or warranty procedures. FAI is coordinating this effort in order to allow interchangeability and some measure of uniformity. This project is being done with the active participation and cooperation of OPM. The GS-1102 classification job standards study at FAI is also related inasmuch as it is likely to develop a recognition of the unique function of contracting officers. The career development studies underway also may identify the contracting officer as a special agent thus requiring special patterns of education, training, and experience. This work will also eventually impact the issue of providing contracting officers with the requisite skill levels.

Part III Regulatory Approaches

To be brief, we will examine only the GSA and the DOI program.* The proposed FAR and FPR language will also be considered.

All in all, GSA Order Adm. 2851.3, dated Dec. 18, 1979, accomplishes for that agency an overall and thorough implementation of COGP recommendations A-12, 13, and 14. Effective on the date of issue it should be implemented within FY 80. While a reading of the whole is recommended the following selected pertinent portions illustrate the scope of the GSA order:

"Background: GSA Contracting Officers (C.O.) serve a critical role in accomplishing GSA missions. When delegated contracting authority, contracting officer's act as agents of the United States in establishing binding legal relationships that obligate the Government to pay for property and services received and to deliver property it sells. Capable and qualified personnel are required to carry out the responsibilities associated with this authority. The present method of assigning contracting officer authority; that is, to organizational positions rather than to individuals, does not ensure this. This order, therefore, establishes a procedure for warranting qualified individuals as contracting officers on the basis of both organizational requirements and individual qualifications".

*Several other agenciea in cooperation with the FAI have similar related efforts in process.

The introductory relevant portion is: "Minimum qualifications of contracting officers consist of a combination of training experience with considerations given to relevant academic credit or degrees earned. The GSA Acquisition Career Planning Boards, to be established, will implement training standards in accordance with joint guidance received from the Office of Acquisition Policy and the Office of Personnel. However, certain core training will be required for contracting officer personnel at various levels indicated below or training requirements can be met by the substitution of equivalent courses. Course equivalencies will be determined by the office of acquisition Policy. In addition, training requirements may be met through the demonstration of career knowledge attainment through testing which will be administered by the Office of Human Resources and Organization. Warrant boards will evaluate candidates based on recommendations of their supervisors, considering experience, education, training, business acumen, judgment, character, and reputation."

The relative organizational position of the contracting officer is established as "Authority shall be exercised by the qualified contracting officer responsible for the processing of the actions, since this individual is the most knowledgeable concerning the transactions. Generally, the organizational location of this individual is the first level supervisor of the personnel actually processing the transactions."

An important cumulative result of the GSA order is that no exceptions are provided for, and qualifications and training are proscribed for any person who is to contract.

As a sample of a smaller agency's efforts we have selected the Dept. of Interior whose proposed procurement bulletin, 14-1.4, is now (early 1980) in process of development and review. It may well be a prototype for other agencies. The background section defines the need and outlines the plan:

"(a) Federal Procurement Regulations 1-1.404 requires that agency procedures be established for the selection, designation, and termination of designation of contracting officers. Departmental policy in the past has been that designation would be made to positions rather than to individuals. Also, only general guidance was provided for the selection, designation, and termination of designation of contracting officers.

(b) Because of new statutory and regulatory requirements regarding federal contracts in the last few years, and the growing visibility and volume of federal contracting, the complexity and accountability of the contracting process have increased significantly. Inherently, the responsibility and authority of the contracting officer have also expanded.

(c) To aid those who perform this function, and to provide the contracting expertise necessary to accomplish management's contracting needs, this bulletin provides further guidance and establishes minimum standards for contracting officers. Delegations of contracting officers authority will now be made to individuals who meet these standards rather than to positions."

Another regulatory effort is in process as the FPR Sec. 1-1.404, is being reviewed as to the provisions regarding the Contracting Officer. The FAI, and others have contributed suggested language. As with most of the individual agency actions, the FPR revision aims at authority clarification, better qualifications, and organizational position. These purposes are expressed in the draft amendment transmittal as: "The purpose of the amendment is to provide for the selection of individuals as contracting officers on the basis of their individual competency. Section 1-1.404 presently provides that agencies may designate contracting officers by name or position. This amendment eliminates the designation of contracting officers by position. It adds requirements that contracting officer selections and designations be made only by the head of the agency, the head of a procuring activity, or their designees. Additional criteria have been added to the list of contracting officer qualifications. The additional criteria require the evaluation of specialized knowledge in the particular assigned field of contracting, and satisfactory completion of procurement training courses that will provide the functional knowledge commensurate with the level of responsibility." The comments from FAI, and others, go to more definitive statements regarding qualifications and the training and equivalence issues.

The OFPP is also preparing to issue the FAR. In part, it provides language related to Contracting Officer status. Subpart 1.6, in the drafts being circulated for comment, in 1.602-1, sets forth the Contracting Officer authority: "(a) Contracting officers have authority to enter into, administer, or terminate contracts and make related determinations, and findings. Contracting officers may bind the Government only to the extent of the authority delegated to them. Contracting officers shall receive clear instructions regarding the limits of their authority. Information on the limits of the contracting officers' authority shall be readily available to the public and agency personnel. (b) Contracting officers shall ensure that all requirements of law, Executive orders, regulations, and all applicable procedures, including business clearances and approvals, have been met prior to entering into any contract." 1602-3, is also a part of the contracting officer arena: "When the contract requires a decision by the contracting officer on a question of fact: Advice and assistance from specialists or superiors shall be solicited and considered; however, the final decision must constitute the contracting officer's own independent judgment." The regulations proposed declare as to selection (and qualification) in 1.603-2; "In selecting contracting officers, the appointing official shall consider

the complexity and dollar value of the acquisitions to be assigned and the candidate's experience, training, education, business acumen, judgment, character, reputation, and ethics." Many comments have been received by the FAR team as to these sections. In preparation for this paper they have all been reviewed, Government entities, the public's and contractor's.

Another related FAI effort with the aid of other agencies, especially OPM, is a classification standards study for civil service contracting and procurement positions. A new OPM factor evaluation system format is being used with large inputs from an occupational survey of 14,000 Federal employees of 26 agencies. This work has produced (early 1980) a draft position - classification standard for the GS-1102 series which establishes a point scale for job evaluation. Interestingly in the positions described there is none called Contracting Officer. Similarly in a list of carefully derived (from the survey and a follow-up interview process) tasks the verbs "obligate," ("direct," "decide," and "manage" do not appear even though they seem to be indicative of the needed tasks of a contracting officer. Therefore, some modification of the proposed draft to describe a contracting officer seems to be in order. The model to be presented hereinafter in Part IV will draw heavily on the classification study but focus on duties and responsibilities. The GS-1102 series more general positions will be modified to indicate, typically at least, that many positions are solely to be supportive of the contracting officer. These changes are in no way meant to detract from the classification study, but rather to complement and extend it for the use of the contracting officer.

Part IV - A Contracting Officer Model

Model Position Description (Duties Section) Senior Contracting Officer:

Major Duties

Pursuant to the authority granted by law the contracting officer:

- Participates in agency requirements formulation and determination procedures.
- Obligates the Government to contractual relations,
- Determines the fairness and reasonableness of the proposed contractual relationship,
- Executes and administers contracts,
- Decides resolution of disputes between the Government and contractors,
- Considers counsel of legal, audit, engineering and other experts in the above actions,
- Reports as required to agency management on actions,
- Takes such actions as are prescribed by law in the acquisition process,
- Maintains a fiduciary relationship as to the Government's best interests.

It is very likely most contracting officers will be drawn from those acquiring experience as GS-1102, this should not be the only source; i.e., if the qualifications are established, a contracting officer could be from any series, e.g., from military or the foreign service sectors.

The FAI is reviewing the organizational levels of contracting officer's assigned and the minimum distance between the head of an agency and the contracting officer, depending on agency organization maintained. Autonomy and independence, in fact, is necessary.

For a second model, consider a contracting officer with authority to enter obligations with an expected total cost to the Government of less than $20,000, and which have a performance period of less than 6 months. The basic model is adapted only to note the limit of authority as a preamble to the duties, the qualifications provide for a lesser experience requirement. Likewise, the

organizational level can be adapted to place the contracting officer in whatever operating level can practically benefit from its own capacity to make the lesser sized procurements noted. Note that no fundamental modification of the obligational nature of the job changes, and the special fiduciary nature of the contracting officer role is not changed.

Part V - Future Approaches

The FAI has an ongoing project which includes a coordination working group with the final aim of harmonizing the regulatory efforts some of which are described above. In addition, the continuing work with respect to classification standards to reflect contracting officer duties and tasks will be consistent with the needs established and described earlier. Further development of the models, and means for providing for the concerns regarding organizational position are to be generated.

Given the mandate of P.L. 96-83 to generate and propose the Uniform Procurement System, the Administrator of OFPP may well use it as a vehicle for presentation and consideration of the contracting officer recommendations A-12, 13 and 14. Ms. K. Williams in her prepared testimony for her Senate confirmation hearing included in her plans for OFPP ". . . a major restructuring of the role of the contracting authority." It is the FAI work on both the regulatory and legislative front described which then finally can be said to provide satisfaction of the COGP recommendations A-12, 13 and 14.

HEW CERTIFICATION PROGRAM

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HEW

ABSTRACT

HEW has established a program of awarding certificates to procurement personnel that complete specified courses, have specified experience, and meet other requirements. The certificate system provides goals for employees and management as to what courses to take and when, and recognizes employee achievement. Although the system is achieving its objective of developing professional procurement personnel, it is being restudied to make sure course material is pertinent, that standards are realistic, and that the administrative aspects are appropriate.

THE CERTIFICATION PROGRAM

Description of the Procurement Certification Program. Under the HEW Procurement Certification Program, an employee may submit an application for Certification to an agency Certification Board. The Board will compare the employees achievement with the standards established for certification. If the applicant meets the standards, the Certifying Official, with the advice of the Board, will award the certificate. If the applicant does not meet the standards, the Certifying Official will refuse to award the certificate and will provide the applicant with a written explanation why he/she was refused.

Current status of the Procurement Certification Program. To date, approximately 350 employees have received certificates. However, in connection with the certification program, many persons have received extensive training in Government procurement thereby hopefully improving the skills of procurement employees in HEW.

Background. In 1977, the former HEW Secretary Califano signed a memorandum specifying a number of actions to be taken to improve the HEW contracting and grant process. One of these actions was to initiate a certification program. In May 1980, Certification Boards were established in all the principal operating components of HEW and in the Office of the Secretary. These boards have met regularly whenever certification candidates have submitted their applications and have appropriately awarded and refused certificates.

Effect of Program. By establishing a certification program, HEW has provided a means of telling employees in procurement and procurement related jobs, what is expected of them in regard to training, skill, knowledge of procurement, performance and experience. As a concomitant to certification, HEW training courses are made available to employees, priorities for training course attendance have been established, and target dates set for employees to obtain their certificates. Supervisors have been made responsible for seeing that their employees are trained and certified on schedule.

Varieties and levels of Certification. The Purchasing Agent Certificate (Level I) requires experience and the taking of courses in small purchase and GSA procurement. This certificate is the only certificate awarded in this area of procurement. The contracting series includes Contracts Official (Level II), Senior Contracts Official (Level III), and Contracts Manager (Level IV). Each successive level of certification requires more training and experience in procurement. Although it is theoretically possible to start at Level I and progress through Level IV, few persons have been able to do so because of the tendency to specialize in either small purchase procedures or negotiated procurement procedures.

Programs Leading to Certification. There are two programs that set forth the requirements to achieve certification. The Basic Program and the Special Program. The Basic Program is the usual program

followed in earning certification. The training and experience required for certification under the basic program are readily available to procurement personnel. The Special Program has the common requirement of National Contract Management Association certification. Because of the comprehensiveness of this certification, the requirement for experience has been lessened and the requirement for taking courses has been eliminated.

Required Courses. A major requirement for certification is successful completion of a number of procurement courses. HEW makes the following required courses available to HEW procurement personnel.

Basic:

Basic Procurement Course
Small Purchase Course
Formal Advertising Course
Negotiated Procurement Course
Contract Administration Course
Cost and Price Analysis Course
Art and Techniques of Negotiation Course

Advanced:

Advanced Negotiated Procurement Course
Advanced Contract Administration Course
Advanced Cost and Price Analysis Course

In addition, HEW offers a Basic Program Officials Guide to Contracting Course and an Advanced Program Officials Guide to Contracting Course. Program officials and evaluation panel members are required to take these courses.

Exceptions. Because of the specialized approach to procurement taken by persons working in the facilities engineering and construction field, a separate set of requirements recognizing facilities engineering and construction oriented procurement courses has been established for personnel working this field.

Equivalency. Because many HEW procurement personnel have obtained their training in procurement in courses outside of HEW, Certification Boards are allowed to determine whether or not these courses are equivalent to HEW courses and to accept them as meeting the HEW standards.

Program Assessment. The HEW Certification system has been in existance for several years and is operating in an apparently acceptable fashion. However, to make sure, a number of assessment panels have been established to review in depth the various aspects of procurement training and certification and make recommendations for improvements. These assessments are now being made and no conclusions are yet available. The areas being studied are:

Priority I

Training Issue
Certification Issue
Equivalency Issue

Priority II

Construction
Course Location

Official Recognition. At the present time Certification provides a structure and an opportunity for procurement personnel improvement. It is not a requirement for promotion or for delegations of authority. However, where certain personnel have signature authority or have been delegated contracting officer authority or preaward review and approval authority, it has become mandatory, as a part of their normal work assignment, to take appropriate courses and to become certified by specified dates.

	LEVEL I PURCHASING AGENT	LEVEL II CONTRACTS OFFICIAL	LEVEL III SENIOR CONTRACTS OFFICIAL	LEVEL IV CONTRACTS MANAGER
BASIC PROGRAM GENERAL EXPERIENCE	1 Year 1102, 1105, 1106 6 months must be in small purchase or GSA purchase	3 Years OR 2 Years plus Outstanding or Sustained Superior Performance Rating OR 2 Years plus Bachelor's Degree (accredited) in related field	3 Years OR 2 Years plus Outstanding or Sustained Superior Performance Rating OR 2 Years plus Bachelor's Degree (accredited) in related field	3 Years OR 2 Years plus Outstanding or Sustained Superior Performance Rating OR 2 Years plus Bachelor's or Master's Degree in related field
SPECIALIZED EXPERIENCE	-	-	2 Years Specialized Contracting - Senior Procurement Position - Contracting Officer, Contract Specialist, Cost Analyst, Procurement Analyst, etc.	2 Years Specialized Contracting - Senior Procurement Position - Contracting Officer, Contract Specialist, Cost Analyst, Procurement Analyst, etc.
PROCUREMENT MANAGEMENT POSITION	-	-	-	1 Year Operational Contracting Officer, Senior Procurement Analyst
SATISFACTORY PERFORMANCE RATING	YES	YES	YES	YES
BASIC PROCUREMENT COURSES	68 hours must include Small Purchase and related course	170 hours must include Cost and Pricing, Art and Technique of Negotiation	170 hours must include Cost and Pricing, Art and Technique of Negotiation OR This requirement may be waived by Board	170 hours must inlcude Cost and Pricing, Art and Technique of Negotiation OR This requirement may be waived by Board
ADVANCED PROCURE- COURSES	-	-	136 HOURS	136 HOURS

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SPECIAL PROGRAM GENERAL PROCUREMENT EXPERIENCE	1 Year (as above)	2 Years	2 Years	2 Years
SPECIALIZED EXPERIENCE	-	-	2 Years (as above)	2 Years (as above)
PROCUREMENT MANAGEMENT EXPERIENCE	-	-	-	1 Year
SATISFACTORY RATING	Yes	Yes	Yes	Yes
NATIONAL CONTRACT MANAGEMENT ASSOCIATION CERTIFICATION	Required	Required	Required	Required

THE IMPENDING DEMISE OF PACE; RAMIFICATIONS FOR STAFFING PROCUREMENT POSITIONS

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ABSTRACT

The Professional and Administrative Career Examination (PACE) will not be long with us. Instead, the Office of Personnel Management (OPM) plans to delegate its authority to examine applicants for ex-PACE occupations to employing agencies. Such agencies will not have PACE to staff the occupations; indeed, they might not be allowed any written test for that purpose. This paper discusses the various staffing instruments that will be available to agencies and the various ways they can be combined to form examinations. The paper also describes OPM's standards for examinations and the process for designing examinations implicit in those standards.

THE ORPHANS OF PACE

As of this writing, the PACE examination has not made the obituary column of the Federal Personnel Manual. This is not surprising, for OPM plans to administer it for several more years. However, one by one, PACE is losing its occupations. One by one, OPM is delegating authority to examine applicants for entry level positions in the occupations. The recipient of each such delegation is the department or agency that has the most employees in the occupation. For instance, the Social Security Agency, which has more claims examiners that any other agency, has been delegated authority to examine applicants for its claim examining positions. Likewise, the Department of Defense, as the major employer for most ex-PACE procurement occupations, will be delegated authority to examine applicants for its procurement positions. It will not be long before procurement occupations are numbered among the orphans of PACE.

Many procurement occupations have been staffed, at the entry level, through PACE. Among them are the following.

Contract and Procurement (GS 1102)

Quality Assurance Specialist (GS 1910)

General Supply (GS 2001)

Inventory Management (GS 2010)

Logistics Management (GS 346)

General Business and Industry (GS 1101)

Property Disposal (GS 1104)

Supply Program Management (GS 2003)

Distribution Facilities and Storage Management (GS 2030)

Packaging Specialist (GS 2032)

Supply Cataloging (GS 2050)

General Transportation (GS 2101)

The Staffing Services Group of OPM has already opened negotiations with the Department of Defense to delegate examinaing authority for the first four occupations on the above list. Under the delegation agreement, the department would develop examinations for it own entry level positions in the occupations. The examinations will be comprised of selection instruments other than PACE. It is OPM's hope to implement the delegation agreement before the close of Fiscal Year 1980. If that hope is realized, the PACE registers will be closed to Defense managers in Fiscal Year 1981, and those managers will instead turn to the department's own newly created registers for entry level procurement positions.

But what of the many non-Defense agencies with positions in those occupations? Their managers will not have access to the Defense registers. Hence, OPM plans to continue PACE during Fiscal Year 1981. Managers in non-Defense agencies will be able to fill their entry level procurement vacancies from the PACE registers throughout that year. Afterwards, OPM plans to devise and administer a new examination of its own for non-Defense agencies.

THE HEIRS TO PACE

Individual claimants. Long was the list of individuals and groups who claimed to be the sole or partial heirs to Howard Hughes. Yet, the list of potential heirs to PACE may be the longer list. The individual claimants alone include the following: (1) Biodata forms, (2) application blanks, (3) reference checks, (4) self-assessment forms, (5) interviews, (6) work samples and simulations, (7) miniature training and evaluation, (8) assessment centers, (9) interest inventories and measures of expected work motivation, (10) the probationary period, (11) achievement tests, and (12) predictive aptitude tests. All but the last two are thoroughly covered in Federal Personnel Manual Bulletin 331-3 of March 6, 1980. (1)

Table 1 briefly depicts these potential heirs to PACE, and it also summarized the strengths and weaknesses to their respective claims to the estate of PACE. Unless otherwise noted, material in the table is taken from the bulletin.

Table 1. Selection Instruments

1. Biodata rating forms

Format:	Multiple choice items on the applicant's past experiences, education, skills, traits, and other such background data.
Strengths:	Low cost per applicant. Validity tends to be high.
Weaknessess:	Criterion-referenced validation is preferred.
	All items on the form must be directly related to the occupation's work.
	Many items on private sector forms are prohibited under OPM policies.

2. Application blanks

Format:	Open-ended items on the applicant's experiences, education, skills, traits, and other such background data. Items are scored by applying predetermined standards.
Strengths:	Low cost per applicant.
	Content validation acceptable.
	Tends to be used in screening applicants for specific types of experience or education that indicate possession of desired skills, knowledge, abilities, and other characteristics.
Weaknesses:	Validity and reliability tend to be suspect.
	Tends to be less used for predicting future job performance when applicants have not had job-related experiences or education.

3. Reference checks

Format:	Questionnaires, phone calls or interviews to obtain data from persons, such as ex-supervisors, who have observed the applicant in the past.
Strengths:	Very useful for doublechecking data from applicants.
	Forced-choice rating forms for appraising the applicant's past work performance have been valid predictors of future job performance in some studies.
	Mailed rating forms cost little per applicant.
	Content validation normally acceptable.
Weaknesses:	Often, few mailed rating forms are completed and returned by ex-supervisors.
	Validity and reliability tend to be suspect, given such problems as the "halo effect" and generosity errors. (2)
	Interviews or phone calls cost much per applicant.

4. Self-assessment rating forms

Format:	Applicants rate themselves on important dimensions of the job.
Strengths:	Research to date has been promising.
Weaknesses:	Still under research as a selection instrument.

5. Interviews

Format:	In a face to face meeting, applicants are grilled by the staffing specialist or supervisor.
Strengths:	Can be useful for evaluating some types of skills, such as verbal communications skills, that are not readily measured by written instruments--if the interviews are structured, standardized, and job related.
	Gives applicants a chance to ask questions about the job.
Weaknesses:	Costs per applicant are high.
	Reliability and validity tend to be most suspect.

6. Work samples and simulations

Format:	Applicants perform actual or simulated tasks of the occupation. In some cases, the performance itself is rated by observers. In other cases, the product alone is rated.
Strengths:	Content validation is preferred.
	High validity.
Weaknesses:	Costs per applicant may be high.

Assumes the applicant already has learned the skills and knowledge necessary for the tasks.

7. Miniature training and evaluation

Format: Applicants are trained and then perform actual or simulated tasks of the occupation.

Strengths: Content validation is preferred.

High validity.

Assumes the applicant has not yet learned the necessary skills and knowledge.

Weaknesses: Costs per applicant are high.

8. Assessment centers

Format: Applicants are subjected to panel interviews, leaderless group discussions, in-basket exercises, problem-solving exercises, or other such situations. Their performance is rated by observers.

Strengths: Reported validities tend to be high.

Content validation is acceptable.

Weaknesses: Costs per applicant are high.

9. Interest inventories; measures of expected work motivation

Format: Much like a computer dating service, attempts to match each applicant with the type of work environment that would best motivate the applicant. A rating form is used to identify the things that tend to motivate the individual applicant, and a job analysis is performed to identify organizations in which those motivators are present.

Strengths: Predicts whether an applicant, regardless of ability, would find the occupation's work, as performed in a particular work unit, to be personally rewarding and motivating.

Weaknesses: Does not measure the ability of a person to perform the occupation's work.

10. Probationary period

Format: Applicants are hired for career conditional positions. During the probationary period, they perform standard tasks under fairly standard conditions with fairly standard training for the tasks. Their performance is closely monitored during the probationary period, and only the best are retained.

Strenths: Very high validity.

Weaknesses: Very costly.

11. Achievement tests (3)

Format: Measures an applicant's possession of skills, knowledge, or abilities that are used in, and are necessary prerequisites to, performance of critical or important work behaviors.

Strengths: Low cost per applicant.

Content validation is customary.

High validity.

Weaknesses: By definition, not useful for selecting employees on the basis of potential who have not had an opportunity to learn the necessary skills and knowledge.

12. Predictive aptitude tests (4)

Format: Measures aptitudes that correlate with ability to master the occupation's work. PACE is an example of such a test.

Strengths: Low cost per applicant.

Weaknesses: Criterion validation is necessary.

Unpopular, due to past adverse impact of such tests.

Group claimants. Any one of the individual selection instruments, or any combination of two or more instruments, may constitute an examination. You could, for instance, decide to interview all applicants and select employees solely on their prowess in the interviews. Alternatively, you could both interview all applicants and ask all to complete application blanks. The interview and application blank, in that instance, would together comprise a single examination, with the score from the interview and the score from the application blank combining to provide a single rating for each applicant.

When two or more instruments form a single examination, it is not necessary that they be administered at the same time to yield a single, overall rating for an applicant. The instruments could be administered serially, with the score from the first determining eligibility for the second. Thus, all applicants might complete an application blank. Only those who score at least 70 of a possible 100 points on their responses to items in the application blank might be eligible for the assessment center. Only those who had the highest scores on assessment

.enter exercises might be eligible for interviews by selecting officials. Only those chosen by the selecting officials would be eligible for the probationary period. Most examinations are serial in this wise.

Why combine selection instruments: One: Such combinations allow you to measure a range of skills, knowledges and abilities that would not be possible with any one of the instruments alone. Achievement tests are not suited to measuring an applicant's skill at oral communication. Interviews are not suited to in-depth measurement of an applicant's present level of knowledge. Tests and interviews together allow both in-depth measurement of the applicant's knowledge level and measurement of the applicant's oral communication skills. Two: such combinations enable you to use a low cost instrument to screen huge masses of applicants with a more precise and costly instrument to rank, in order of hiring preference, the few that score at least 70 to 100 points on the low cost instrument. Thus, an application blank might inexpensively reduce 100,000 applicants to 1,000. The surviving thousance might then be subjected to an assessment center to determine which three individuals will be interviewed by the selection official.

More than one heir? It is quite possible that two or more examinations will inherit the same ex-PACE occupation. Separate examinations are allowed for separate audiences. Traditionally, most professional and administrative occupations have in fact been served by three examinations: (1) PACE, (2) cooperative education programs (applicants who enter such programs are judged in terms of their academic prowess and work experience with the agency, although of late some applicants have also had to score at least 70 points on PACE before conversion to career-conditional status), and (3) examinations to select lower level employees for upward mobility target positions. These by no means exhaust the possibilities. There could be a separate examination, for instance, for graduates of baccalaureate procurement programs. Such an examination might involve a written achievment test and assessment center or simulation exercises. At the same time, there could be a separate and distinct examination for applicants who have not had any past experience or education of direct relevance to the occupation. The latter examination would obviously be geared to potential, and it might involve an application blank and assessment center exercises.

Given all the possible selection instruments, all the possible combinations of those instruments, and all the possible audiences that might merit a separate examination, the list of potential heirs to PACE may be long beyond count.

STANDARDS FOR DESIGNING EXAMINATIONS

Sources of the standards. The Federal Personnel Manual system and title 5, Code of Federal Regulations, contain standards for every phase of the examination process: developing the examination, scheduling it, announcing and publicizing it, administering it, and registering the applicants who pass it. This paper will only detail standards for developing the examination. Such standards, for the most part, are found in part 300 of title 5, Federal Personnel Manual Supplement 271-1, (5) and the Uniform Guidelines for Employee Selection Procedures (Uniform Guidelines) (6). These documents together prescribe four basic standards for designing examinations: (1) Relevance, (2) Validity, (3) Objectivity and Reliability, and (4) Adverse Impact. The fifth basic standard: Veterans Preference, is prescribed in section 337.101 of title 5, Code of Federal Regulations. The following table shows the relationships between each of these authorities and the five basic standards for designing examinations.

Table 2. Sources of Standards for Designing Examinations

Standards	5 CFR 300 & 337	FPM Supp. 271-1	Uniform Guidelines
Relevance	X	X	X*
Validity		X	X*
Objectivity & Reliability		X	
Adverse Impact			X
Veterans Administration	X		

*The more rigorous standards in the Uniform Guidelines are mandatory only when there is a finding of adverse impact. Otherwise, the standards in 5 CFR 300, 5 CFR 337 and FPM Supp. 271-1 alone apply.

Relevance. Under section 300.103 of title 5, Code of Federal Regulations, job analyses are mandatory for every examination. In the words of that section, such analyses must identify:

"(1) The basic duties and responsibilities;
(2) The knowledges, skills and abilities required to perform the duties and responsibilities; and
(3) The factors that are important in evaluating candidates."

Job analyses are also required in FPM Supplement 271-1 and the Uniform Guidelines, as part of the validation process.

Validity. In the words of FPM Supplement 271-1, "an applicant appraisal procedure is valid if it measures the knowledges, skills, abilities, and other employee characteristics it is intended to measure." To say this another way, the validity of an examination is the accuracy with which it measures what it purports to measure. There are three separate strategies for validating an examination, and there are separate standards in the supplement and the uniform guidelines for each.

Criterion-referenced validation studies are studies in which you correlate scores on the examination with ratings or other measures of job performance.

For example, you might correlate scores on an achievement test with supervisory ratings of performance. In such a study, you might have one hundred applicants take the test, hire them all, and five years later match test scores with the ratings. If all applicants who scores at least 70 of a hundred points on the test have a rating of at least 7 on the ten point performance rating scale, while all applicants who scored less than 30 have ratings of less than 3 on the ten point performance rating scale, you would conclude that the test has virtually perfect validity. If there was no correlation at all between test scores and performance ratings, the test would have no validity. And it is possible for the test to have negative validity; for test scores to be inversely related to performance ratings.

The standards in Supplement 271-1 for criterion-referenced validation are few. You must be able to show statistically that scores on the examination do better than chance in predicting an applicant's rating on a criterion which is legitimately based on the needs of the Governments. The criterion can be a measure of later success on the job (predictive validity) or it can consist of measures of job success that are collected at approximately the same time as scores on the examination (concurrent validity). As examples of criterion measures, the supplement lists "work samples, objective measures of productivity, ratings," and "tests." The standards in the Uniform Guidelines are much more detailed. For instance, the Uniform Guidelines not only require the examination to do better than chance in predicting an applicant's rating on the criterion measure--it must be "statistically significant at the .05 level of significance, which means that it is sufficiently high as to have a probability of no more than one in twenty to have occurred by chance." There is not room enough in this article for even a summary of the standards in the Uniform Guidelines for criterion validation.

Content validation studies are studies in which you show that every item on the examination represents a skill, knowledge or ability that is in fact an important part of the job and logically related to successful performance on that job. In fact, most content validation studies are inseparable from the task of building the examination itself--in the course of analyzing the job, isolating the key skills, knowledges and abilities that are necessary at the entry level to learn the job, and designing items for examinations which measure a person's grasp of those skills, knowledges and abilities, you will ordinarily collect all the data that is necessary to confirm the content validity of the examination.

The standards in Supplement 271-1 for criterion-referenced validation again are few. You must have evidence from a careful job analysis that the skills, knowledges and abilities being measured are vital to the job. There must also be competent evidence of professionally determined content validity. There are also standards for the process by which a content valid examination is constructed. There must be a systematic analysis of the job. Based on data from the job analysis, you must identify and define the knowledges, skills and abilities necessary for successful performance of the job. Finally, you must systematically define the various measurable characteristics inherent in those skills, knowledges and abilities; and must key the measurement methods and devices to those characteristics. These, in brief, are the standards of the supplement. The standards of the Uniform Guidelines are again much more detailed. For instance, the Guidelines delimit the use of content validation, stating that it is not appropriate for "demonstrating the validity of selection procedures which purport to measure traits or constructs, such as intelligience, aptitude, personality, commonsense, judgement, leadership, and spatial ability." Again, the standards are too detailed to summarize in this paper.

Construct validation, the third and last type of validation study, is performed by identifying "constructs" that underlie the most common and critical work behaviors of the job. The examination is then keyed to those constructs. In the words of the Uniform Guidelines, "construct validation is a relatively new and developing procedure in the employment field, and there is at present a lack of substantial literature extending the concept to employment practices."

<u>Reliability and objectivity</u>. Supplement 271-1 requires that all examinations be "reliable" and "objective." An examination is reliable, says the supplement, "if the scores obtained with the procedure are consistent and stable." An examination is objective if "it elicits responses which are observable, and if they can be recorded and reported in a precise, specified way." Obviously, there is a relationship between validity and reliability. An instrument that is not reliable is not valid, although a reliable instrument is not necessarily valid.

Despite this linkage, it is possible to study the reliability of a selection instrument separate and apart from studies of its validity. Thorndike and Hagen (7) describe three basic approaches to appraising reliability: test/retest (in which the same individual is subjected to the same instrument on two or more occasions), parallel test (the same individual is subjected to several different versions of the examination), and split half tests (in which two parallel tests are merged but scored separately after administration).

The supplement does not mandate such studies. Instead, it prescribes certain standards for the design of the examination which tend to ensure reliability and objectivity. The supplement states that each appraisal procedure must include:

"(1) Standard directions for conducting or completing the procedure.
(2) Standard scoring or summarizing instructions.
(3) The method of interpreting (e.g., converting, weighting, combining) the scores or summaries and applying them in the context of other methods used in the total evaluation process leading to ranking of applicants.

(4) A method for recording scores so that the record is meaningful and usable in the future.

(5) Where appropriate, provisions for reporting the scores in meaningful terms to applicants and appointing officials."

Adverse impact. Standards for appraising adverse impact are found in the Uniform Guidelines. These standards require agencies to track their hires by minority group and sexual categories. If the selection rate for any one of these groupings is less than 80% of the rate for the group with the highest rate, there generally will be a finding of adverse impact. For example, an agency might hire two of every ten white males that apply for positions in the agency. If it only hires, at the same time, one of every ten black males who apply for the same types of positions, the presumption is adverse impact.

When there is a finding of adverse impact, the agency has two choices. It can scrap its present selection instruments. Or it can demonstrate the validity of its selection instruments under the rigorous standards of the Uniform Guidelines. However, it is not enough to demonstrate validity. Section 3B states that "where two or more selection procedures are available which serve the user's legitimate interest in efficient and trustworthy workmanship, and which are substantially equally valid for a given purpose, the user should use the procedure which has been demonstrated to have the lesser adverse impact. Accordingly, whenever a validity study is called for by these guidelines, the user should include, as part of the validity study, and investigation of suitable alternative selection procedures and suitable alternative methods of using the selection procedure . . . ." It is this provision that may have spelled the doom of PACE, for, no matter how valid the PACE examination, it could scarcely have been argued that PACE is the only suitable instrument for selecting employees.

Veterans Preference. Under section 337.101 of title 5, Code of Federal Regulations, the examination must result in numerical ratings on a scale of 100. Veterans with a rating of at least 70 must get an additional five points or ten points, depending upon their circumstances.

A PROCESS FOR DESIGNING EXAMINATIONS

The above standards, taken together, entail the following basic process for designing examinations.

A. Analyze the occupation's work to identify the representative tasks of entry level positions and rank such tasks in order of criticality and importance.

B. Analyze the most common and critical tasks to obtain detailed information on the following aspects of each task.

1. End products of task performance.

2. Conditions under which the task is performed.

3. Measures of task performance.

4. Knowledges, skills, and abilities that are vital to task performance.

C. Develop the examination

1. Identify the knowledges, skills, abilities and other characteristics that will be measured by the examination.

2. Determine the specific examination instruments which will comprise the examination.

3. Identify the skills, knowledges, and abilities to be measured by each instrument, and the number of items on the instrument to be devoted to each.

4. Design each item on the examination.

5. Test each item for clarity, reliability and validity.

6. Develop procedures for scoring items on the instrument and combining the scores from all the instruments.

7. Test the overall examination for reliability and validity.

8. Administer the examination.

9. Periodically re-test the examination, item by item and as a whole.

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EFFECTIVE TEAM INTERFACES

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THE MANAGER, THE POLICY MAKER, AND THE RESEARCHER: A TEAM FOR EFFECTIVE PROBLEM SOLVING

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ABSTRACT

Research based responses to changing conditions tend to be more effective and lasting than ad hoc reactions. But, to be applied effectively acquisition research requires teamwork between managers, policy makers, and researchers. Ways and examples of how to obtain this teamwork are presented. Research implementation techniques are highlighted.

A steadfast commitment and aggressive follow-through are imperative if an organization is to make positive changes to the status quo. There are many bases for determining the proper kind of change to make - judgement, experience, intuition, increased information, staff study, "lessons learned," and applied research. The imperatives of commitment and follow-up, it is submitted, tend to favor a research based approach if lasting change is to be achieved. Consequently, this paper will deal with research as a basis for response to a need for change and the roles of the manager, the policy maker and the researcher in making good use of research.

A need for change (in this paper, a "problem") arises in diverse forms and circumstances. A problem can be recurrent or a singular event. It can be conventional (i.e., involving usual terms and relationships) or non-conventional. It can be found in one division or many divisions.

The characteristics of a problem often dictate what kind of resources to assemble to approach problems. The table below suggests the composition of typical problem-solving teams. The headquarters manager is concerned typically with problems involving many divisions. If the problem is recurrent, he will call in his policy chief and perhaps selected division managers and/or researchers. If the problem is non-recurrent he may call in any or all of the three groups.

TEAM COMPOSITION FOR PROBLEM SOLVING

TYPE OF PROBLEM

	NON-RECURRENT				RECURRENT			
	CONVENTIONAL		NONCONVENTIONAL		CONVENTIONAL		NONCONVENTIONAL	
TYPE OF PROBLEM SOLVER	MANY DIVISIONS	ONE DIVISION	MANY DIVISIONS	ONE DIVISION	MANY DIVISIONS	ONE DIVISION	MANY DIVISIONS	ONE DIVISION
Manager: HQ	X		X		X		X	
Manager: Division/ Field	X[1]	X	X[1]	X	X[1]	X	X[1]	X
Policy: HQ	X[2]		X[2]		X		X	
Policy: Division/ Field				X[2]		X		X[2]
Researcher	X[2]	X[2]	X	X	X[2]	X[2]	X	X

[1] SELECTED MANAGERS; [2] CONSULTATION

If the problem is non-conventional, the headquarters executive is likelier to use a researcher for applied analysis. Other resource mixes and uses are depicted in this table, but it is noteworthy that the researcher may be called in for virtually any application. Generally when the problem is not recurrent, the solution is likelier to be tailored to the individual case and the researcher will work with the appropriate field or division manager. An Army example of collaborating at this level is depicted in an analysis of acquisition alternatives for rocket systems (1). The rocket system project manager was confronted with the decision to remain sole source or develop a second source resulting in a buy-out or a split award. The PM was aware that techniques had been applied to other programs to evaluate the alternatives but was not confident of the applicability to his program. The Army Procurement Research Office assisted the PM in tailoring competition savings forecasting techniques that it had developed for a set of other systems to the rocket program. Close collaboration between the manager and researcher in this instance resulted in a systematic trade-off analysis which gave the PM a more confident basis and credible support for his decision.

With a recurrent basis for action, a standard solution (i.e., policy), generalized from multiple events to avoid repetitively resolving the symptoms of the same issue, may be warranted Here a policy maker may call in the researcher. An example of a top level policy manager calling on the researcher to work on a recurrent problem is represented by the Army's study on the determining and forecasting savings from competing previously sole source/non competitive contracts (2). Here the research activity was asked to study a representative sample of systems to develop a methodology which could be used on an Army-wide basis to estimate and forecast savings resulting from competition. To assure broad applicability of the study, the research activity was assisted by a study advisory group, consisting of representatives from engineering, procurement, logistics, comptroller, and other disciplines. Contractor analysts and field operators also participated. The report and techniques developed in this research resulted in a recurrent basis for action. Though specialized adaptation of the forecasting algorithm may be required, collaboration between high level policy makers and the research activity facilitated the development and use of an acquisition planning method with wide applicability.

Although the research approach has the potential to give the most powerful solution to the manager or policy-maker, there are many reasons the researcher may not be solicited for his aid or his work not used. Research is a relatively costly and time-consuming business and can be simply inappropriate for a particular problem. Research is foreign to many decision makers by their training and experience (3, p. 46). It is not intuitively appealing to them, and they do not trust a process they do not understand. Decision-makers may feel they need specific and absolute proof and feel uncomfortable with such research trappings as probability statements and research that makes inferences from studies not directly related to the specific problem (3, p.46;4, p.53) Decision makers may feel research findings leave them no discretion or lead away from a favored position. They may, in fact, have had poor experience with tendered research that was irrelevant, difficult to interpret, or just poorly done.

Even when research is employed, there is no guarantee the findings will be accepted. Here a new set of factors comes into play. Not only are the characteristics of the manager/decision maker important, but also those of the organization involved, the research proposal, the researcher, and the relationships among these factors (5, p. 30).

Once the research is given to the client, four responses are possible: rejection for rational reasons, rejection because of "resistance," acceptance without implementation, and implementation (adapted from 5, pp. 27-29).

It is understandable that a study might not be used on economic or technological grounds. If operations will not be significantly better with research recommendations or if their adoption requires excessive cost or time, rejection is indeed rational (6, p. 148). Moreover a decision maker cannot use research that is not on the subject or is articulated poorly (4, p. 53). As one observor put it: ". . .good intentions and an algorithm do not necessarily make an application" (7, p. 44).

A client may reject research results with less rational justification. There are institutional barriers in an organization of any size (6, pp.150-151). Getting a change adopted will often require coordination among many jurisdictions. Recent legislative initiatives (e.g., affirmative action programs, environmental impact statements) may constrain adoption. The client's or his office's priority may be too low to get commitment on a significant change recommended by research.

Political/ideological barriers may be impediments to research acceptance (6, pp.151-153). Change may be threatening to an influential party (or to client). Apathy may also cause resistance. Again, after the research is completed the client may not be comfortable with the results because of his training, aptitude, fear of loss of discretion, or lack of confidence in research per se. One study pointed out that the decision maker's thinking process can influence acceptance (5, pp.38-40 and pp.108-109). A decision-maker who customarily uses analytic reasoning to reduce a problem to a set of causal relationships is naturally more receptive to the researcher's approach. But a person who uses heueristic

reasoning emphasizes workable solutions with the use of analogies, similarities to other problems, common sense and intuition. The heuristic reasoner may suppress research findings, the analytic solution, if their presentation is counterintuitive.

Research findings may be accepted but not successfully implemented if understanding does not take place (5, p. 28). In fact, acceptance of research recommendations can lead to organizational instability if improper implementation is attempted. Often the charge is heard that a certain technique does not work, when in fact it is improperly applied. "Lip service" or perfunctory acceptance may be caused by a willful attempt only to appear progressive. Acceptance with good intentions but without understanding can be a show of blind faith in research or a belief that understanding will eventually follow.

Of course, operational implementation is what the researcher wants (5, p. 28). Operational implementation can be achieved in two degrees, sustained and autonomous, each requiring different levels of effort from the researcher. Where the client has a good overall understanding of the research but has not participated in great depth, sustained implementation can be achieved. But this will require that the researcher have longer term interaction with the client to insure proper application, particularly with high levels of uncertainty. An example of sustained implementation in the Army is a study of Acquisition Strategy Development (8). The research activity developed the model for development, convinced management of the need, and identified the areas of application for acquisition managers. But, because of the complexity of plans needed to guide acquisition strategy and the variety of circumstances in which they are applied, management was obligated to retain the research team to develop planning procedures and decision mechanisms to assure full success of the concepts developed in the original research (9).

If the client has explicit and complete understanding, the researcher's continued input will not be needed; such autonomous implementation (5, pp.28-29) is the ideal result of applied research. The Army has realized this result in the area of proposal evaluation and source selection. Research leading to a field guide with structured procedures for evaluation of proposals did not need to be followed up by the researchers because of management's thorough understanding of the need from the outset and operators' substantial experience in field to which the improved procedures applied (10).

What can be done to increase the use of research-based management and policy? In terms of the initiation of a research study, the responsibility begins with the manager. The manager must decide if the problem is recurrent or beyond one division or branch. If the manager decides he should solve the problem, he must first decide if research is appropriate. Is there enough money, time, data, etc.? The manager must guard against bias for or against research.

Once research is determined to be the basis for decision making, the manager has the initial problem of asking the right questions. A clear, attainable goal must be articulated in terms of ends, not means (6, pp.54-55). The decision-maker is likelier to have success with a small amount of change and not push the state-of-the-art too much (6, p. 157). Design of any implementation strategy should consider the ultimate user (6, p. 158). The decision-maker as the research client should nurture a good researcher-client relationship to insure an operationally oriented study and encourage researcher involvement in applications (11, p. 984). It is also the client's responsibility to get high level support for research. In a major Army research project which led to the development of a computer-assisted total value assessment model (12), the command procurement director client convinced the Commander General to endorse the results. This support led to the later application of the model to a major proposal evaluation and source selection endeavor (13).

The headquarters manager must take an active role in soliciting and promoting research by making selected problems known in research forums and commenting on on-going research (4, p. 54). In the Army Development and Readiness Command, the Director of Procurement and Production includes research promotion as part of the periodic meetings he holds with the procurement director's of the Commodity Commands of DARCOM. Solicitations for projects and reports of projects are made at these meetings. Senior Army acquisition officials take active parts in the Acquisition Research Symposium.

Acquisition policy makers have a special responsibility to shepherd research applications. One approach to this responsibility is offered by practicing policy researchers (14, p. 66):

The policy-maker publishes proposed areas and invites comments of all kind (including research findings) from a selected or unlimited population.

He reviews comments on the policy areas.

He writes up policy alternatives and rationale.

He invites and reviews comments on policy alternation.

He has meetings and/or hearings.

He decides on policy.

Such a procedure is, of course, not appropriate for all policy, but where it is warranted, this type of approach can bring on the benefits of increased openness and vigor.

The researcher has a role also in insuring his services are solicited. He must be a marketer for research, finding out the problems and needs of decision makers (14, p. 67) and giving a good image of research. He must make decision-makers aware of the work already done and in a timely manner.

The researcher must keep implementation as part of his research plan and start planning on it at the very beginning of the work (5, p. 30). Constraints should be identified as early as possible. Reading the client is important. How does he think? Can he be educated? Should the research be modified to accommodate to the decision-maker? The researcher has to design the research to meet the problem (14, p. 67) and make it implementable. The work must be understandable and useful and demonstrably result in an improvement over the status quo (7, p. 45).

Obviously the research must be based on good assumptions and representative samples and be professional in approach. But beyond that, the researcher has to translate and disseminate the results to enhance their effective application (15, p. 55). The researcher must go beyond presenting the study and the findings to explaining the concept of the research.

The manager, policy-maker, and researcher must guard against rejection of research on "irrational" grounds and against acceptance of research without the manager's or policy maker's understanding. The key here is communication. The researcher has to express all that he is doing, and educate the decision-makers on research form and substance. The decision makers must verify what is needed and give feedback on what is done.

In summary, a problem in today's organization should be solved systematically. The proper team must be selected. The choice of whether to use research or less rigorous approaches should be made on rational bases. The problem of implementing research is the job of the researcher and policy maker as well as the manager and must be of as much concern as the quality of the research itself.

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FROM RESEARCH NEED IDENTIFICATION TO RESULTS IMPLEMENTATION

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ABSTRACT

This paper reflects the authors' experience as participants in a series of research projects to develop a capability to measure the effect of production rate changes on weapon system cost. The paper describes the series of projects, overall results and lessons learned and implications to acquisition managers and researchers about major issues important to acquisition research.

INTRODUCTION

The acquisition process and the acquisition environment continously demand that acquisition managers and researchers search out new ideas and management concepts to improve the process. Some of these concepts are readily accepted for implementation by management while others require varying degrees of tailoring and testing before they meet management's acceptance. Quite often acquisition research takes several years to solve problems faced by acquisition managers. Also, research benefits are not usually realized in the short term; sometimes it takes several years to realistically measure research benefits.

This paper summarizes a series of research projects that addressed a problem identified by the Director of Contracting and Acquisition Policy at Headquarters United States Air Force (AF/RDC). General results of the projects are discussed and lessons learned are also presented in terms of implications to acquisition managers and researchers.

COMPLETED RESEARCH

Background. In 1974, AF/RDC directed the Air Force Business Research Management Center (AFBRMC) to establish a project to develop practical methodology for measuring and forecasting the impact of production rate changes on weapon system cost. The AFBRMC developed a project objective to concentrate on airframe direct manufacturing labor because of data availability at various sources in the aircraft industry and the cost of direct labor dollars necessary to fabricate and assemble airframes.

Acquisition management concern about production rate impact on cost had been expressed at various times before 1974. However, acquisition researchers studying the problem arrived at varying degrees of success and failure in providing practical tools for acquisition managers to use on actual programs. Acquisition managers and their functional staffs required a method that was practical and readily available for their programs.

The learning curve concept was the primary direct labor estimating tool for several years in airframe production. The concept proved useful to estimators working problems associated with production programs where rates were fairly stable. But, unexpected changes in annual budgets and uncertainty in expenditures had adverse impacts on estimates made using the learning curve. The concept is constrained because it is based on quantity only; no consideration is given for production rate (or time). Therefore, the acquisition research challenge was to develop a practical approach for including production rate in forecasting direct manufacturing labor requirement airframe programs. This challenge required empirical study of production rates and their relationships to direct airframe manufacturing labor requirements.

Initial Research. One researcher to accept the challenge was Col Larry L. Smith, an Air Force Institute of Technology (AFIT) Ph.D. candidate at the University of Oregon. Smith agreed to conduct the research as part of his dissertation requirements. With support from the AFBRMC and the Aeronautical Systems Division Comptroller (ASD/AC),

Smith visited three aircraft manufacturers and collected data and information on past aircrame programs. Using McDonnell-Douglas F-4, Convair F-102, and Boeing KC-135A airframe data, Smith conducted an empirical analysis of production rate effect on direct manufacturing labor.[7] The result of this research was a procedure (in the form of a computer program) for measuring and forecasting direct labor requirements based on varying production rates. Mathematically, the equation is an extension of the basic learning curve equation. Figure 1 illustrates the two concepts in graphical and equation form for airframes.

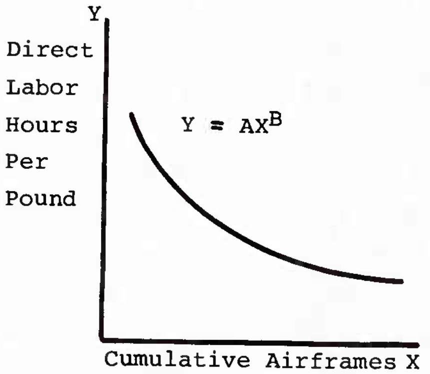

Figure 1a. Standard Learning Curve Concept

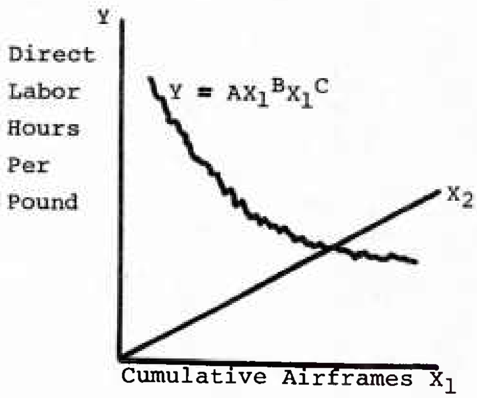

Figure 1b. Extended Learning Curve Concept

Figure 1. Comparison of the Standard Learning Curve Concept and Extended Concept

Finally, Smith used the computer to conduct analysis to compare the two concepts as tools for measuring and forecasting direct labor. Test results revealed that the extended concept was a potentially better estimating tool.[7] This research effort was considered significant because of its rigor and the nature of the procedure developed by Smith. The procedure offered a potentially improved estimating tool and a practical computer program that provided a good basis for replication for other products and eventual implementation.

Follow-on Replications. Due to his success in meeting his research objective, Smith felt some temptation to generalize his research results to other airframe programs, but these results were necessarily limited to the F-4, F-102, and KC-135A airframe data.[5] Therefore, this limitation formed the basis for the first follow-on replication and validation of the extended model as an estimating tool.

The first replication of Smith's work was conducted by an AFIT thesis team, Captain Duane Congleton and Major Dave Kinton. Congleton and Kinton tested Smith's procedure using direct manufacturing labor data gathered from the T-38 and F-5 airframe programs.[2] Congleton and Kinton replicated Smith's work by examining 15 different combinations of T-38 and F-5 data and using regression analysis to evaluate Smith's earlier results.[6] The research team also tested the predictive ability of the new procedure by using it to generate estimates and comparing them with those generated by the standard learning curve model and actual data. Results of this replication confirmed Smith's findings and further substantiated the new procedure as an improved technique for estimating airframe direct labor requirements.[6]

After the new rate-based procedure was validated for use on airframe programs, the next logical step was to test it as an estimating tool for other systems and products.

The next replication of Smith's work was conducted by another AFIT thesis team, Captains David Stevens and Jimmie Thomerson. Their objective was to test the rate-based procedure for use on avionics programs.[8] Stevens and Thomerson used data collected from the

Magnavox ARC-164 Radio and Teledyne Data Signal Converter Programs. As with airframes, this research team found that production rate had a significant effect on avionics direct manufacturing labor requirements. Further, they found the rate-based procedure was a better estimating tool for avionics production programs. Another significant result of the Stevens and Thomerson effort was to implement the procedure. They refined Smith's original computer program and placed it in the COPPER IMPACT computer program library under the name PRODRATE.[8] This initiative made the procedure available to all subscribers of the time-sharing system of users of the COPPER IMPACT library.

While Stevens and Thomerson were conducting their research, another AFIT thesis team, Michael Crozier and Edward McGann conducted a replication of Smith's work for jet engine programs. Crozier and McGann analyzed direct manufacturing labor data gathered from the J-79, TF-41, and F-100 engine programs.[3] This research team obtained mixed results in their efforts. They found that production rate had a significant relationship to direct labor in three out of six test cases. However, in one case, PRODRATE was a much better forecasting technique than the standard learning curve. Crozier and McGann also concluded that, based on their findings, complexity of jet engines production programs limited applicability of PRODRATE and the standard learning curve concepts used in their research. Therefore, based on Crozier and McGann's study results, PRODRATE may or may not fit a particular jet engine manufacturing programs. Further analysis should be conducted on jet engines to improve confidence in using PRODRATE for such systems.

The most current effort in the series of replications and tests is that of another AFIT thesis team, Captains Scott Allen and Mike Farr. At this time, Allen and Farr are preparing to test PRODRATE against direct manufacturing labor data for air launched missiles. Their data base is gathered from the Boeing Short Range Attack Missile and the Hughes Maverick missile programs.[1] Analysis is incomplete and results on this effort will be available in July 1980.

Overall Results. Before addressing lessons learned and implications of this research experience, it is appropriate to summarize this series of projects in terms of general results and PRODRATE validity as an estimating tool.

Figure 2 represents an orderly knowledge development approach used by the AFBRMC to illustrate the relationship between concept or model validity and application uncertainty.[4]

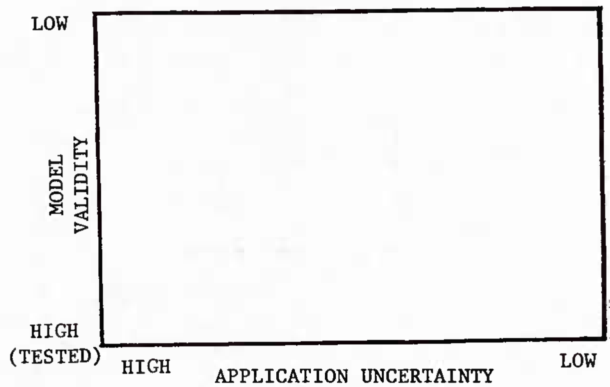

Figure 2. Orderly Knowledge Development

Application uncertainty is used as an indicator to partially assess and explain acceptance of a concept or model for implementation. Not invented here resistance is frequently encountered by researchers and their attempts to gain acceptance of their results. This reaction is usually experienced because potential user organizations do not have a way to assess whether a proposed concept will perform as advertised.[4]

Validity is a measure of model or concept performance in terms of testing against specific objectives and criteria.[4] Figure 3 illustrates the use of the orderly knowledge development approach for PRODRATE.

Overall results and PRODRATE's uncertainty and validity status are illustrated in Figure 4. Figure 4 also summarizes PRODRATE's progress toward acceptance and implementation. Therefore, as the illustrations indicate, overall research has been successful. The next major step to full implementation will consist of field tests and general application to programs where direct labor costs are uncertain.

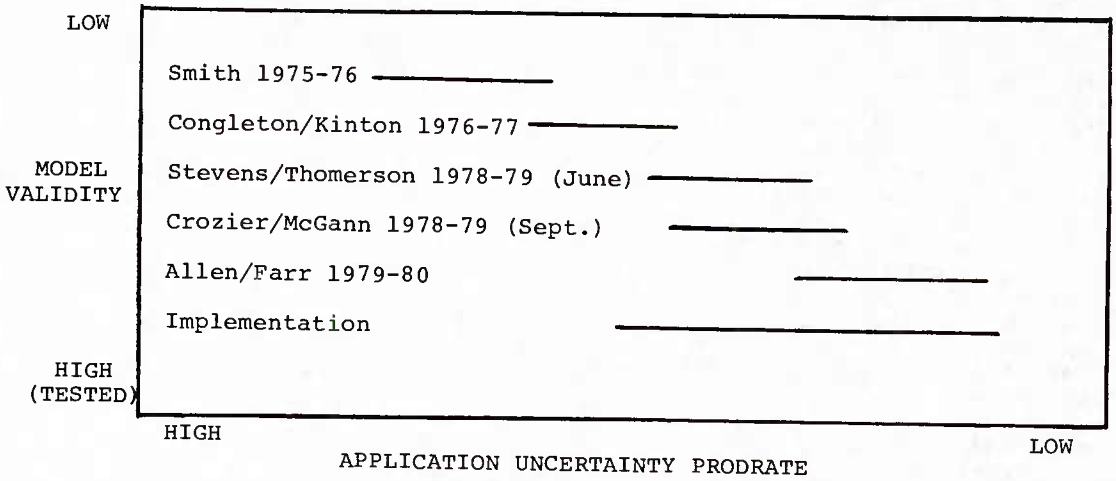

Figure 3. Knowledge Development for PRODRATE

RESEARCHER	PRODUCT LINE	UNCERTAINTY	VALIDITY
Smith	Airframes	Medium	Medium
Congleton/Kinton	Airframes	Low	High
Stevens/Thomerson	Avionics	Low	High
Crozier/McGann	Jet Engines	Medium	Medium
Allen/Farr	Missile Frames	Unknown	Unknown
Overall		Medium	Medium

Figure 4. PRODRATE's Uncertainty/Validity Status

LESSONS LEARNED

The authors' participation in the various phases of development and replication testing of PRODRATE has been a rewarding experience in terms of lessons learned about positive and negative factors that significantly contribute to successful acquisition research.

Many issues that inhibit successful testing and implementation of research results are behavioral in nature. Attitudes of potential users are key elements that troubled the authors. The "not invented here" syndrome presents a significant barrier to successful implementation. Understanding PRODRATE presents no significant challenges to cost/price analysts already familiar with the learning curve concepts, but the authors encountered the syndrome early in the testing phases. In one instance, a research sponsoring organization ignored research results after making significant contributions. A participating contractor put PRODRATE to use as a result of a research teams' request for data support. Government analysts from the sponsoring organization were later surprised when confronted with a PRODRATE related position during negotiation. The lesson learned is that the attitude of the benefactors to acquisition research is critical to implementation of results.

A significant element in PRODRATE's successful development was inclusion of a research "broker" to coordinate key research activities from need identification to implementation. For example, a key role played by the AFBRMC was support to researchers to obtain data. Many projects have failed because a data source has "dried up" for various reasons even when data does exist. The AFBRMC directly assisted the researchers to identify and obtain data from weapon systems contractors. Direct contact with senior company officials resulted in positive support in all but one situation. However, the one case did not inhibit project completion because alternative data sources were identified. In the one case the researchers were told data was available for a price. The other contractors participated willingly and now own a share in the experience. In every case (except one where a government data source was available) the research broker played a significant role in gaining access to data considered company sensitive by contractors.

Another important benefit of a research broker is continuity. Long term research projects quite often experience turnover in research participants. Such turnover often kills a project. In the case of PRODRATE, the AFBRMC kept the need for continuing research alive and well by keeping the PRODRATE case file open, monitoring progress and striving to maintain an effective team interface.

IMPLICATIONS TO ACQUISITION MANAGERS AND RESEARCHERS

The lessons learned from the PRODRATE experience have some important implications to acquisition managers and researchers.

Implications to Management. An important message to management is that effective results take time. In the case of PRODRATE, the development and testing of the procedure has taken six years from need identification to its present status of initial implementation. Quite often acquisition managers need or want instant results and benefits. However, instant results often are only temporary fixes to problems that will occur again and again and quite often become costly mistakes.

Implications for Researchers. An important factor for successful research results implementation is careful planning on the part of the researcher. Awareness of a potential user's needs must be continuously in the researcher's mind. Results need to be translated into practical terms with a specific objective. Clear identification of research need is also critical to project completion. One seldom achieves the ill-defined goal.

General Implications. The key to the success of PRODRATE's development and testing has been an effective interface between acquisition managers, researchers and data sources. Close relationships between researchers and managers provide sound understanding of one another's problems and needs. Cooperation has been a critical factor to data access on each research effort; without data, empirical research is a useless venture.

Finally, the continuity of research should be a key planning element. The linking of the research tasks toward an overall end contributes to research success. The research broker concept is a tested means for providing that linking.

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TRANSFER OF ARMY CONTRACT MANAGEMENT TECHNOLOGY

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ABSTRACT

The author proposes that Army contract management technology should and might be better transferred from one organization to another by means of selective solicitation, condensation in digest form, and distribution of ideas developed by, and for use of, Army contract managers. The overall problem area is considered, along with the people, organization and regulatory factors that cause the need for better technological transfer and contribute to the difficulty of achieving it. The type of costs and benefits are also outlined.

INTRODUCTION

Point. One way to improve the interface between acquisition managers, operators and researchers would be to improve our ability to transfer contract management technology from one organization to another, a large and long known problem area. This might be accomplished by selective solicitation of ideas from those organizations which seem to do certain tasks well, by careful condensation of the ideas, selective distribution to those organizations that might benefit, and by repeating the cycle continually.

Purpose. The purpose of this paper is to surface the thought that potential utility is available from the foregoing point, to identify some of the factors bearing on the overall problem area, and to outline the costs and benefits of the act of developing the digest of ideas.

Limitation. The assessments of the author have evolved after participation during the decade of the 1970's in research projects, inspections and management reviews of contracting problems exclusively at Army contracting offices. Accordingly, the point is primarily addressed to Army managers of the contract function, although other services and agencies would likely benefit as well.

PROBLEM AREA

General. Contract management technology exists in abundance at some Army activities. That same technology is virtually unknown to managers at other installations, and the absence of that knowledge is the root cause of many of their management and contracting problems. Although most contractual actions reflect credit upon the Army, there is room for improvement, and there is more room at some organizations than at others. Furthermore, it is likely that the gap is widening where some offices are becoming progressively worse, unaware that others are making noteworthy improvements.

One might reasonably expect that any large Government or industrial organization, with multiple branch offices engaged in management and performance of essentially the same function, would in some way be able to assure effective transfer of lessons learned about the function from one branch office to another. But transference of technological "know how" in contracting is persistently problematical even though the purpose and steps in the process are similar from one contracting office to another. At best it is yet a goal in the Army, rather than a reality.

Examples. While every contracting organization cannot operate the same way, it is reasonable that some concepts and techniques work better than others and could be beneficially exported. Numerous examples of the fact that better techniques need to be transferred are evident to a discerning observer in every category of concern, some of which are as follows:

a. Planning of annual programs for contract execution and individual procurement actions must be accomplished to some degree and in some way by all Army contracting organizations. Some do it exceptionally well; others scarcely do it at all.

b. Organization of contracting offices and interfacing disciplines must be based on some organizational philosophy. But the variances are dramatic in style and effectiveness, including the use of legal specialists, pricing and audit specialists, contract specialists, research and engineering specialists, policy specialists, logistics specialists, review boards, and the overall team concept. Centralization concepts about performance of the contracting function are not standardized throughout the Army and management of the contracting resources, workload, backlog and priorities is accomplished differently by virtually every organization.

c. Direction for execution of the contract process takes multiple forms in different organizations, some of which are excellent and some

ludicrous. Almost every organization uses different standing operating procedures, delegations of authority, and contracting instructions and in many cases the nature of guidance and the topics covered are quite dissimilar.

d. Coordination among the various customer elements and participants in the contract process varies to a point that each organization is almost unique. Even the roles of the key participants tend to be dissimilar, including the authoritative role of the head of a contracting activity (HCA), principal assistant responsible for contracting (PARC), chief of a contracting office, contracting officer (KO), contracting officers' representatives (COR), ordering officers, and authorized callers under blanket purchase agreements.

e. Control techniques to establish checks and balances, to review and measure results and quality aspects, and to surface recurring problem areas are not uniform in style, application or effectiveness.

f. Operational techniques, even within the same category or phase of the materiel life cycle, vary over a wide spectrum including: procurement package and specification preparation; solicitation; source selection; evaluation; negotiation; price reasonableness determination; formation of contract type; structure of contractual documents; award; property, funding and administrative actions; execution of contract modifications to change, increase, or extend the scope; documentation and maintenance of contract files, and so forth.

FACTORS BEARING ON THE PROBLEM AREA

People, organizational and regulatory factors bear on the problem, cause the need for better technological transfer and contribute to the difficulty of achieving it.

Organizational growth is limited by its people. The contracting process is so multifaceted and dynamic that process refinement is a never ending need. Most outsiders and many higher level officials, however, cannot readily detect and define low quality levels and recurring problem areas in a contracting office so that new alternatives can be examined. The task rests almost entirely on the shoulders of the personnel internal to the organization. Achievement of continuous organizational growth in capability, therefore, is dependent upon the individual manager and operator to minimize negative attitudes, defensiveness, and over zealous competitiveness which impede growth. The learning process almost must be voluntary or it doesn't occur, and real growth of a contracting organization tends to be little more than the accumulation of individual self-improvements. The task at hand is to elicit receptiveness to new ideas, responsiveness and cooperativeness of the individuals.

Complexity cannot be isolated. Ideally all complex contracting actions might be delegated to a single skilled organization for intensive management. In part, the Army has achieved this goal in that complex large dollar value fixed price contracts for production and cost-reimbursement type contracts for development have been assigned to the subordinate commands under the US Army Materiel Development and Readiness Command (DARCOM). It would be wishful thinking, however, to believe that other contracts are noncomplex, whatever the type and dollar value and whichever may be the phase of the life cycle of the procurement action. Any contract issued by any office may be (and often is) beset with substantive problems which require professionalism of the highest order to resolve. Therefore, the task of transferring knowledge is one of transferring it to all contracting offices, not merely an isolated few.

This situation has been exacerbated by recent national policy decisions relative to Commercial-Industrial-Type-Activities (CITA). Posts, camps and stations all across the Army are now being called upon to contract out for requirements previously accomplished by in-house Government resources. Contracting problems attendant to CITA procurements are very complex, yet the inherent capability of some of the contracting offices to cope with these problems is relatively low and cannot be quickly enhanced. The task at hand is to try for enhancement.

Major Army commands (MACOM's) use different contracting approaches. The Army, which has over two hundred contracting offices, is organized so that the several MACOM's (DARCOM, Corps of Engineers, Communications Command, Training and Doctrine Command, Forces Command, Health Services Command, Office of the Surgeon General, Commissary Command, Western Command, overseas commands, etc.) have diverse missions where requirements for contractual actions differ in terms of type, complexity and dollar value.

While one MACOM may not necessarily be "blind" to techniques employed by other organizations, each MACOM tends to adopt its own approach toward the contracting function and as it evolves, the style tends to become more unique rather than more similar. This natural tendency to differentiate and "go their own way" is due to differences in commodity orientation and life cycle exposure. It is also due to variances in emphasis on contracting by the respective HCA's, other formal and informal leadership, personnel capabilities and constraints, priorities, customs and localized methods which tend to become institutionalized as maturity sets in.

A particular technique which may be an improvement in one organization could be misunderstood, considered nonapplicable, or viewed as a step backward in another office. The task is to rationalize these factors, situation by situation.

The law and regulation are sometimes misunderstood. Although many facets of contracting are

covered, the law, regulation, contracting instructions and even standing operating procedures ("the book"), are not "how to" manuals and do not constitute a substitute for management "know how" and basic expertise in the contracting process. The depth of procedural detail, as to how to perform and manage specific contracting functions, is purposely minimized to provide maximum latitude for effective mission accomplishment under differing situations. Officials of higher echelons generally prefer to state goals, objectives and desired results and to rely on the mangerial expertise and discretionary judgment of lower level officials, rather than provide specific direction as to how tasks are to be accomplished. Most informed managers and operators understanding that general principle and act accordingly.

A mystique is often associated with the contracting function, however, which causes contrary action by some people based on a misperception that the law and regulation is intended to be the primary fount of management and technical "know how". This misperception that "the book" tells all provides a false sense of assurance that innovativeness and additional knowledge is not needed. Some of the distorted perceptions which confound the technology transfer process are that:

a. Procedures and form, as well as policy, are virtually dictated by "the book" and therefore, operational adherence to "the book" is almost a rote clerical process.

b. There is one right prescription for management of the function and that has largely been identified and directed in "the book."

c. The effectiveness and efficiency of the process is being controlled in some manner by officials with centralized decisionmaking authority who are responsible for the results of the process because they are responsible for the direction of the process.

d. Managerial or operational shortfalls are largely curable by more intensive reading and understanding of "the book," or by making inquiries of higher level functional managers who have some influence over the contents of "the book."

e. Where "the book" does not provide guidance, almost any technique is acceptable if it is defensible in a given situation, notwithstanding the availability of a more logical technique.

f. Where command and staff managers are only indirect participants in the acquisition process, safe deference can be made to the judgments of the more directly skilled professionals in the contracting office who are involved in application of "the book."

g. Anyone who is experienced at applying "the book" tends to honestly believe that he/she understands "the book" as well as or better than anyone else, and therefore, new ideas are viewed with disdain and often rejected out of hand.

h. Additional "know how" is not really welcomed because the typical contracting office is so overwhelmed with workload and so inundated with guiding information that the guidance received can scarcely be well catalogued and assimilated throughout the work force, much less well applied to practical problems of the moment.

APPROACHES TOWARD IMPROVEMENT

Existing approaches. Better on-the-job training and formal education in and outside Government can be provided. Motivation can be increased for individual mobility, professional contact and coordination with external organizations, and participation in professional associations. Better use of symposiums and conferences can be developed.

Certainly motivation can be increased for individual professional pursuit of the relevent literature available from the Federal Acquisition Institute, National Contract Management Association, Defense Documentation Center, Defense Studies and Logistics Information Exchange, other industrial and Government publications, Government/DOD/service-sponsored pamphlets and newsletters, reports from Congress, General Accounting Office, Army Audit Agency, Army Procurement Research Office, and so forth. All the ideas available from such sources tend to have practical and specific value to contract managers. However the information is often overly general and appealing to the broad audience with limited value to a manager and operator in need of "know how" applicable to a specific job.

It is necessary of course, to use decisions by the Comptroller General and the Armed Services Board of Contract Appeals as direction for procedural change. But excessive reliance on those methods of knowledge transfer is questionable. Those bodies are not directly responsible for mission accomplishment and decisions in one case can come back to "haunt" as well as help managers and operators working another case.

New approach. One new approach would be for top management to recognize the technological transfer difficulties in the contracting profession and acknowledge the need for some device or mechanism to better organize and facilitate the specific effort, such as development and selective distribution of a digest of ideas developed by Army contract managers for potential use by other Army contract managers.

COST AND BENEFITS

Costs. Organizations and individuals would have to take the time and make the effort to talk with one another to identify, define, share, read, think about and try ideas that might be helpful. At least a few people would have to be dedicated to the goal and manage the effort to initiate and guide discussion conferences, as well as monitor, screen, condense ideas, and exercise

selectivity as the ideas are gathered and disseminated. All of that effort would involve costs.

To be most useful the ideas should be developed, indexed for reference, and made accessible in relatively uniform categories. The key aspects of management should be included which are applicable to all contracting work at all contracting activities: planning, organization, direction, coordination and control. The key operational steps in the contract execution and administration process at all contracting activities should also be established as categorical areas of concern, starting with receipt of a requirement and ending with the closing of a completed contract. Other miscellaneous categories may have recurring applicability and should also be identified for use. Certainly, each of the roles of the authorized contracting executives would deserve a categorical designation, including the Army Acquisition Executive, HCA, PARC, chief of the contracting office, KO, COR, ordering officers, and authorized callers under blanket purchase agreements. All of that effort would involve costs.

Benefits. Better contracts should result. New ideas would be available at the operator's desk as informal, nonmandatory guidance which may influence the structure of individual procurement actions and ultimately all contracts throughout an office. Effective contracts can occur over a handshake or be written in pencil on a single piece of paper signed with an "X," if the seller and buyer can protect their respective interests in ways other than through recourse to our legal and regulatory enforcement system. The whole notion underlying the evolution of procedural change is that better, more effective methods have been devised and better methods will be devised in the future -- increment by increment, than use of the technology of yesterday.

Better management should result. As management meetings are conducted to evaluate local problems and make trade-off decisions, it is conceivable that matters being considered might be similar to matters previously considered and effectively resolved by other organizations. The digest of contract management ideas might be an aid in their decisionmaking processes.

Better problem resolution and resource allocation should result. The digest of ideas concept probably would have a natural way of surfacing problems about which no one in the Army seems to have a good solution. That by-product would help provide an alert to managers at various levels that additional attention is warranted in the area; that additional manpower, more intensive management, or special controls may be needed; and that concentration by in-house Government and outside consultants and researchers may be necessary to find ways to cope.

Better acquisition strategy should result. Commanders sometimes do not know how to best use their own contracting capability due to a lack of understanding as to what their contracting capability is, what is can become, and what it might be called upon to do. Gaining timely, effective and cost efficient access to the resources of industry to help carry out missions is often easier said than done. Yet as in-house personnel resources are increasingly constrained, Commanders find it necessary with increasing frequency to reach toward industry. An effort to routinely share contract experiences between installations and activities should improve their ability to do that.

SUMMARY

Perhaps it is naivete and unrealistic to expect occurrence of any amount of meaningful sharing of contract management and operational "know how," other than that which is imposed by mandate from higher headquarters. Certainly technological skills can never be equally distributed due to the diversity of organizations in the Army and natural differences between the capabilities and exposure of individual professionals. But equality of capability is not needed, while a bit more even distribution is needed.

People, organization and regulatory factors that bear on the problem area have been discussed herein to identify the need for better knowledge transfer and the difficulties associated with achieving it. There are many available approaches toward leveling out the peaks and valleys of capability, all of which may be fruitful.

One new approach is available and this paper has pointed out the potential for the sharing that might occur on a voluntary basis, provided some facilitating medium could be employed such as a selectively utilized digest of contract management ideas.

Certain direct costs would be involved to dedicate a few people to the effort of developing, digesting, and distributing the ideas. Indirect costs would also be associated with the effort to read, think about, and utilize the transferred ideas.

The benefits could be substantial in that better individual contracts should result as well as better management, problem resolution, resource allocation and acquisition strategy.

A METHODOLOGY FOR MONITORING AND EVALUATING THE OUTPUTS OF A FEDERAL RESEARCH LABORATORY

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ABSTRACT

This is a report on a preliminary test of a methodology for monitoring and evaluating the outputs in several fields/programs of a large federal research laboratory. Six pilot areas were selected, representing major units, programs, and fields within the laboratory. Based on interviews with key individuals in each program and examination of relevant documentation at the program and laboratory level, several score of potential output indicators were identified. These were fed into a stage model of the R&D/Innovation process for each selected field/program. The model also included identified barriers, facilitators, and transfer mechanisms for the transition of outputs between stages. Steps in developing and introducing a monitoring/evaluation system are described, as well as ways of integrating such a system into routine management activities of the laboratory, including current reporting and programming procedures.

INTRODUCTION

All R&D-performing organizations can expect to be asked, from time to time, how they are contributing to the longer term goals and the shorter run objectives set for them. For "imbedded" or "captive" R&D laboratories, which belong to an industrial company or a mission-oriented government agency, such questions are generally raised within the context of the goals, objectives or missions of the parent organization. They may include such indicators as: security, protection of resources or the environment, extending our capabilities into new areas (e.g., space or underwater), making a profit, or growing in a satisfactory manner.

In the case of "stand alone" R&D-performing and supporting organizations, similar questions might be raised, but the context is much less well-defined than the above situations. The mere raising of the question does not necessarily reflect dissatisfaction with the performance or outputs of such organizations, but is in keeping with the current general climate of questioning the contributions, value, health, and other aspects of the nation's overall R&D/Innovation process. This climate is manifested by two major national inquiries (the Domestic Policy Review and the Joint Economic Committee Studies) into the status of our innovative capabilities and performance, relative to other countries and to our own past performance, as well as the many individual inquiries into the health of R&D/Innovation in individual companies and Federal agencies which support and/or conduct R&D.

Although precise and quantitative measures of the output and impacts of R&D in general are currently beyond the state of the art, policy makers and managers continually try to obtain "numbers" or "number surrogates" to help them "measure" the effectiveness and contribution of the R&D they are responsible for and interested in. Many of these numbers and measurements have very low credibility and efforts are being exerted by some organizations to improve them. Where these efforts accurately and credibly reflect the nature of the particular R&D programs being evaluated and are not preconceived general measures which are not applicable to the particular field being analyzed, they can be of great help in a number of aspects of the management of R&D/Innovation.

Where, as is often the case, such attempts at quantitative measurement are not properly derived from and related to the particular R&D program, the environment in which it is being performed, and the "downstream" context of the potential application, the effort can be damaging as well as fruitless. If, for example, an R&D program is designed and conducted to generate information and ideas in a certain area, but is tasked with "not having contributed to" another area, to which it has no operating connection, misunderstanding and conflict are likely to occur. This frequently happens in the work of corporate central laboratories, which may be only nominally connected with short-term, highly-focussed work in product divisions, and in government agencies which are faulted for not having "cleaned up the environment", "solved the energy crisis", or "cured cancer".

METHODOLOGY OF THE STUDY

This brief study was undertaken as an exploration of the application to R&D programs of a large federal R&D laboratory of a methodology that we have been developing for several years for ident-

ifying potential indicators of the outputs and impacts of research, development, and innovation (R&D/Innovation) activities in a wide range of technical fields. The methodology involves use of a multistage flow model of the overall R&D/Inovation process from the laboratory stage through application, implementation, and impacts on the society and the economy. It attempts to obtain, from knowledgeable participants in and observers of a technical field, candidates for potential indicators of output at the various stages. Such indicators can be used for a number of purposes, including: R&D strategic planning, project selection and resource allocation, monitoring of the process while it is occuring, and evaluation and audit procedures downstream in the process.

Two major modes of data acquisition were used in the study:

a) Interviews with participants in a sample of six divisional programs in the laboratory and knowledgeable observers of these programs from the R&D community.

b) Analysis of documents. The primary documents used for extracting potential indicators were supplied by specialists in the sample program areas. These included program plans, descriptions of programs, and some quasi-technical reports that contained statements of goals and objectives of particular programs.

The data obtained through the interviews and documentary analysis were combined to form sets of potential indicators. No statistical analysis was made of responses on the interviews because respondents did not represent a large enough sample of people "in the field" for any given subarea and because we were looking primarily for candidates for output/impact indicators for use in planning, monitoring, and evaluating R&D programs in the laboratory. A great deal of work has to be done subsequent to this small study to: further refine the lists, operationalize and scale the indicators, combine indicators into composite groupings, pilot test their use for monitoring and evaluation, and implement routine use of such indicators in planning and managing R&D in the laboratory.

The laboratory studied is a somewhat special (although not unique) situation relative to many other R&D organizations, since it does not have one "client" or "sponsor", but rather does work for and is supported by many organizations both inside and outside the Federal Government. The beneficiaries or impactees of their work can be found in most areas of R&D itself, throughout industry, and in many areas of application of technology to the economy and society. This broad mission is a consequence of its wide-ranging program that cuts across many technical fields.

In many cases, the "clients" or "participants" in given programs cannot be fully indentified, and in other instances, either there are no formal "transfer" mechanisms for the outputs produced by the laboratory, or such mechanisms are viewed as inadequate. This is particularly true when the beneficiaries of its R&D work are in essence "secondary" impactees, that is, people and organizations who benefit from the outputs of its R&D yet are not the prime sponsors or clients of such work.

Attempts were made early in the study to identify the "clients and sponsors" of the laboratory and its programs. The list includes:

A. The Congress and its committees

B. The budgetary and "watchdog" agencies (e.g., OMB, GAO)

C. The Federal Government as a whole and as individual agencies and programs, ranging from agriculture to health and defense

D. Industry--specific sectors, individual firms, special groups and industry as a whole

E. The scientific and technical community--universities, industrial R&D laboratories, the social entity known as "the body of knowledge", and other components of this community such as government R&D labs and agencies (e.g., EPA, NIOSH, NASA, etc.)

F. Professional associations and selected professions such as physicians, dentists, lawyers, firefighters, artisans, etc., in terms of new materials and processes, standards, and advanced professional education

G. The individual and ultimate consumer, citizen, or taxpayer who foots the bill for R&D and benefits (or suffers) from the impacts of science and technology.

H. Foreign countries in all sectors, both "highly developed" and developing.

I. State and local governments--although the channels to them may be less direct than to some of the federal agencies and may require layers of intermediaries.

J. Others, such as civic organizations, community groups, judiciary systems, etc.

Guiding the study was a general conceptual flow model of the overall R&D/Innovation process, encompassing the various stages from laboratory to market or application and beyond, in terms of longer run impacts of R&D outputs (direct and less direct). We have been exploring the utilization of this model for several years in a number of short and long-term studies, across a wide range of technologies. It emphasizes output indicators all along the process and linkages between R&D outputs and social/economic indicators. In addition, it focuses on the many kinds of factors or parameters which can serve as barriers or facilators (in some cases both) to the flow of outputs between the stages along the process.

The flow model contains these entities:

A) The R&D Process itself

B) Transformation and Diffusion Activities

C) Social Sub-Systems

D) The Society and the Economy

and these "flows":

1) Inputs to the R&D Process

2) Immediate or Direct Outputs from R&D

3) Intermediate Outputs of R& D or Inputs to Social Sub-Systems

4) Outputs of the Social Sub-Systems

5) Ultimate Outputs of R&D

Flow models were developed for each of the sample programs and lists of output indicators were compiled for each program. Approximately 250 candidate indicators were identified, covering all stages of the R&D/Innovation process for the sample programs.

RESULTS OF THE STUDY

One outcome of the study was a methodology for monitoring and evaluation of outputs and impacts of the laboratory's R&D programs. It includes these steps:

A) Select indicators from each program and stage

B) Operationalize and scale the indicators

C) Rank or rate indicators for importance

D) Assign an internal person for monitoring/evaluation for each program/field

E) Assign a laboratory-wide person or group for coordinating monitoring/evaluation

F) Design monitoring (how are we doing) and evaluation (how did we do) forms

G) Pilot test forms and procedures for at least one budget cycle

H) Integrate use of forms into regular reporting responsibilities of managers

I) Design control charts for use in monitoring system

J) Establish signalling and follow-up procedure

K) Hold orientation and training meetings on monitoring/evaluation methodology

L) Carry out periodic audits of the monitoring/evaluation system

M) Feedback results of monitoring/evaluation and provide continual technical assistance to program managers

Finally, implications of the proposed monitoring/evaluating methods were explored for several related management areas in the laboratory and several technical aspects of applying the methodology:

A. Project formulation, idea flow, and proposals for new programs/projects/fields of activity

B. Project selection and resource allocation

C. Relations with the laboratory's relevant communities: sponsors, clients, and the technical community

D. Feasibility of data collection

E. Cost/benefits of the proposed methodology

F. The need for an introductory test period

Figure 1 represents the flow diagram developed for one of the sample programs studies. It contains sample indicators for each of the relevant stages in the "Lab-To-Application" flow. In addition, this flow diagram lists the barriers and facilitators identified by the respondents and documentary sources which may affect the flow of outputs from one stage to another.

Figure 2 presents extended lists of candidate or potential output indicators all along the flow from laboratory to implementation and social/economic impact. Of particular note in Figure 2 is the decomposition of the program's "client set" into six major groupings of potential users or impactees of the R&D outputs of the program.

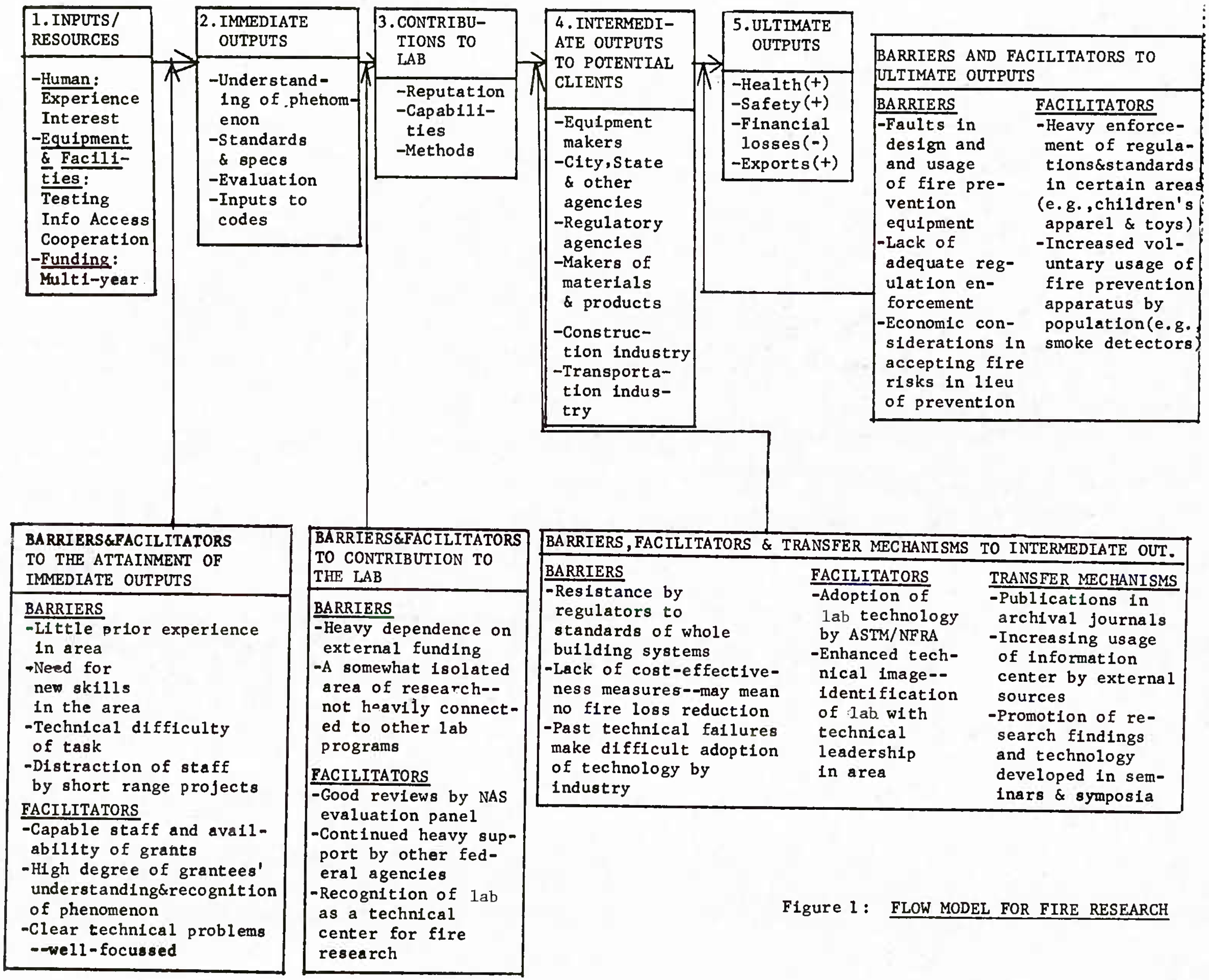

Figure 1: FLOW MODEL FOR FIRE RESEARCH

Figure 2: INDICATOR LISTS FOR FIRE RESEARCH

1. Inputs/Resources

Human Resources
-core of scientific and engineering capabilities of high quality
-skills in various aspects of fire research
-interest in the subject matter

Equipment and Facilities
-updated equipment and testing lab facilities
-access to information and fire statistics
-cooperation of entities involved in fire detection and fighting

Funding
-required levels of funding from the various sources interested in fire research for the multi-year program

2. Immediate Outputs

Understanding Fire Phenomena
-combustion product toxicity
-ignition sources
-propagation properties
-mechanisms and effects of fire phenomena

Detection and Suppression
-detection and smoke control studies and apparatus
-fire properties of materials and products

Studies and Technical Information Transfer
-large scale fire studies
-introduction of fire safety evaluation systems into life safety codes
-introduction of design systems for development of life safety codes

3. Contributions to the Lab
-establishment of the lab as a reputable research center, thus enhancing lab reputation
-development of testing methods and provision of testing services for fire control and fire suppression instruments
-development of standards and codes for a variety of clients, thus contributing to lab's role as the nation's key technical developer of standards and codes
-development of scientific, technical and analytical capabilities in a high priority area
-addition of infrastructure and personnel to lab capabilities, thus increasing the lab's size and strength

4. Intermediate Outputs (Contributions to Potential Clients)

4a. Equipment Manufacturers
-standards and testing techniques for fire prevention and suppression
-testing services for manufacturers on safety and suppression apparatus
-supply of technical information on fire research and development

4b. Municipal, State and Other Agencies
-information, standards and codes for the development of building, safety and other codes related to fire prevention and control
-general and specific assistance in problems of standards and codes
-information and standards related to inspection and enforcement of codes and regulations by municipal, state, and other governments

4c. Construction Industry
-standards and information regarding usage of building materials to reduce fire hazards
-standards and information on fire behavior for the purpose of construction of private and public structures which have fire control features
-testing services and information regarding usage of new materials in construction to reduce fire hazards

4d. Regulatory Agencies
-standards and testing techniques and information
-updated knowledge on fire ignition, propagation and control for issuance of regulations and their updating

4e. Manufacturers of Materials and Products
-standards, information and testing techniques for the manufacturing of fire retardant materials and products (e.g., children's apparel, toys, etc.)
-information, standards and codes on flammability properties of materials

4f. Transportation Industry
-standards and information regarding production of means of transportation with lower risks of fire
-standards, codes and information regarding means of fire suppression for transportation vehicles

5. Ultimate Outputs (Contribution to Society and the Economy)
-reduction in mortality and morbidity due to fire
-reduction in financial loss due to fires
-increase in exports of fire resistant materials and products
-increase in exports of fire control devices, instrumentation and information
-increase in public safety due to improved fire control

FUNCTIONAL VALUE OF THE INDUSTRY MURDER BOARD

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ABSTRACT

This paper deals with a recent development and an innovative approach tested by the Armament Division on selected major acquisitions. This approach is referred to as the "Industry Murder Board." The Solicitation Review Panel (Murder Board) reviews the Request for Proposal (RFP) just prior to release. The Industry Murder Board allows for interplay between government and industry prior to the Murder Board. Due to industry's participation in this aspect of the acquisition cycle, many parts of the RFP package can be revised to incorporate industry's suggestions and comments where appropriate. The overall result is that there is a clearer understanding of the government's requirements. Also, the amount of uncertainty in the final solicitation can be reduced by this streamlining of the contractual document. This paper will explain the Industry Murder Board process and its possible ramifications on major government solicitations.

BACKGROUND

Within the past few years many efforts have been made to improve the RFP process and thus make government acquisition more efficient and effective in meeting our strategic requirements while dealing with an ever shrinking defense budget. The first attempt in this direction was through the use of the Government Murder Board implemented by AFSC in January 1974. The main purpose of the Government Murder Board was to allow for various government personnel to review the RFP, incorporate lessons learned from earlier experiences, and insure that all necessary requirements were incorporated. The end result was hopefully to reduce the level of uncertainty placed on contractors by more clearly relating government needs to industry. The problem with this approach was that everyone involved wanted to make sure their own areas of interest were incorporated into the RFP. Instead of decreasing the RFP to a more understandable and realistic package for industry to follow, it was increased and the original intent was compromised. However, the Air Force is currently making an attempt to reverse this strategy.

INTRODUCTION

The Business Strategy Panel (BSP) followed the Government Murder Board in July 1974. Its function is to attempt to incorporate lessons learned early on in the acquisition strategy into the RFP process. The problem here is that comments offered by the panel are strictly advisory in nature and therefore need not necessarily impact the RFP.

Following the BSP came the Draft Request for Proposal (DRFP) in February 1976. This was a first attempt by the Air Force to let industry submit their comments on the RFP and give their views on where time and money could be saved during the contractual effort. However, even though there are complaints from industry about requirements and specifications, there is a reluctance on their part to submit comments to the DRFP for fear that a competitive edge will be given up in some areas. There also does not seem to be enough motivation on the part of the government to thoroughly review comments submitted or respond sufficiently back to industry concerning their impact, and therefore does not give industry the incentive to keep good comments flowing in.

NEW INITIATIVE

The Armament Division of Air Force Systems Command (AFSC/AD) has been making some progress in the area of improving the RFP process through the use of a new acquisition technique referred to as the Industry Murder Board. The Industry Murder Board was devised in an attempt to allow government to more clearly relate their requirements to industry. Under this approach, industry receives a copy of the DRFP to review and evaluate, and selected representatives from both government and industry come together in an open forum to discuss and make oral comments and recommendations for improvement of the final RFP package. The contention here is that by allowing for this type of interplay between both groups, many aspects of the RFP can be revised; specifications can be made more clear and concise, unnecessary and costly requirements can be deleted, ultimately an overall schedule and cost savings can

result. Initial experience tends to indicate that industry are more likely to let their views be known in this type of environment where there is a two-way channel of communications. As comments and suggestions for improvement of the RFP are offered, immediate and direct feedback can result. Lines of communication are opened up and an early-on dialogue is established which can carry right on through to contractual relations. Those suggestions which cannot be immediately resolved are carried over into the Government Murder Board which follows, where they become mandatory for resolution. The final RFP package is released soon after the Government Murder Board. Industry can then compare the final to the DRFP to see just exactly how effective their suggestions were in impacting the final package.

AFSC/AD developed the concept of the Industry Murder Board and has had successful experience with its use on two selected major defense programs. In both cases the overall evaluation of the usefulness and benefit of the Industry Murder Board to RFP preparation was very good. Industry showed enthusiasm in their willingness to participate and many comments and suggestions for improvement were offered and later incorporated into the final RFP package.

One measure of success of the Industry Murder Board is viewed to be how it is perceived by industry and government. There has to be a comfortable feeling between the two groups and they have to be willing to open up and interchange ideas. A positive "let's work together" atmosphere has to be established early on and carried through to completion. The fundamental criteria for judging the success of the Industry Murder Board is whether or not the final RFP has been improved upon. Has goldplating been taken out? Does the document clearly communicate our minimum military requirements? Will incorporated changes save us from paying for something we really don't want? Improvements to the final RFP are desirable and should reduce the amount of uncertainty in the final solicitation by streamlining our contractual document, eliminating unnecessary "cost drivers," clarifying any ambiguities, and assisting in defining a complete understanding of the government needs and requirements. Clarification early on should minimize contractor time and schedule impacts downstream during the progression of the contract. These factors equate to real dollar savings for the government.

In organizing an Industry Murder Board, several factors are taken into consideration. The first, Selective Use, is considered in deciding what programs can benefit most from the Industry Murder Board. Major defense programs where industry feedback is very desirable and where the sources are limited are prime candidates for use of this approach. Limited attendance from both government and industry is encouraged in order to avoid an uncontrollably large group. Government personnel are limited to panel chairman, program manager, lead engineer, contracting division chief, and procuring contracting officer (PCO). Attendance is limited to three key personnel from each industry represented, including one key executive, one person from contracts, and the program manager. The key executive is included to give an overall view of company policy as opposed to the program manager, who's first interest is usually in the program.

Starting out with a structured review was a major factor in the success of the Industry Murder Boards held at AD. A copy of the DRFP was sent out to each member of industry involved. This was accompanied by a letter requesting suggested comments for discussion. From the responses received, an agenda consisted of those areas of the RFP which industry and government felt were salient. Non-attribution was considered to be an important factor in the success of the Industry Murder Board. Individual companies are more relaxed and feel freer to offer up their views when they are not identified with the comments they submitted. The minutes of the meeting also are written such that suggestions come from industry as a whole as opposed to individual companies.

CONCLUSION

The Industry Murder Board certainly would not be feasible on all programs, but it can be very useful on major defense programs where the large defense dollars are spent. Although it is a relatively small innovation to the acquisition process, a few such ideas grouped together could conceivably have a dynamic impact on the overall way the government acquires its weapons systems. It seems that today, more than ever, with inflation and so many problems springing up abroad, it is important for the United States to concentrate on getting the maximum benefit possible out of the dollars spent. If we are to maintain our respected position as the major military-industrial power in the world community, government and industry alike will need to work together for the benefit of all. The Industry Murder Board seems to be a worthwhile push in that direction and is currently being pursued by other product divisions within AFSC.

The research which led to this paper included contacts with various government contracting personnel directly associated with the Industry Murder Board. The experimental cases developed thus far have put the wheels into motion for a major breakthrough which could impact the contracting environment of the 80s.

THE INTERFACE BETWEEN THE DOD MANAGER, THE OSD POLICY-MAKER AND THE ACQUISITION RESEARCHER - A STUDY OF MANAGEMENT BY COMPULSION

By

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ABSTRACT

The acquisition policy-maker, manager and researcher are faced with a myriad of challenges and opportunities (problems and roadblocks) in a variety of areas: socio-economic programs mandated by Congress and the President, lack of adequate resources and employee motivation to accomplish the required tasks, a decreasing defense industrial base, micromanagement at all levels, proliferation of legislation and directives changing the procurement environment, revisited management issues and indecision, etc. This paper attempts to address the team effort required to resolve these issues and accomplish the DOD's main acquisition objective - that of fielding and supporting mature, cost-effective weapons systems to the operating forces.

INTRODUCTION

Acquisition pertains to the management of activities for the development, fielding and support of systems or items. Within the DOD, contracting, technical management, program financial and business management, requirements establishment and logistics management pervades the entire acquisition process. Within DOD, each Service and OSD sponsor and are engaged in applied acquisition research to improve acquisition management capability and credibility. Acquisition continues to become more complex, resulting in a patchwork of laws, methods, regulations, procedures and administrative requirements. Old problems remain unresolved as new ones continue to arise. This severely impacts the acquisition cycle by lengthening the time required to procure new weapons systems; simultaneously, the United States requires that the most modern weapons be available for the nation's defense. The major thrust of the acquisition research program is three fold:

- Correct and refine acquisition procedures on a continuing basis and cope with acquisition problems as they surface;

- Design the optimum method of giving effect to new acquisition initiatives and policies and expose them to test and evaluation experiences; and

- Achieve innovative improvements, develop training materials, and participate in research on a DOD-wide and government-wide basis.

Major recent DOD acquisition research studies which have had a significant impact on the acquisition process (not intended to be all inclusive) are:

1. Report of the Comission on Government Procurement. Commission on Government Procurement, 1717 H Street, NW, Washington, DC 20006. December 1972.

"The Commission on Government Procurement was created by Public Law 91-129 in November 1969 to study and recommend to Congress methods to promote the economy, efficiency, and effectiveness of procurement by the executive branch of the Federal Government."

This report presents the 149 recommendations resulting from this extensive study. The report consists of 10 parts in four volumes. (LD 28809, 28809A, 28809B, 28809C).

2. Report to the President and the Secretary of Defense on the Department of Defense. By the Blue Ribbon Defense Panel, Washington, DC, 1 July 1970, LD 25811.

This report presents the results of the Panel's efforts to study, report, and make recommendations on:

"(1) The organization and management of the Department of Defense, including the Joint Chiefs of Staff, the defense agencies and the military services, as it affects the department's mission performance, decisionmaking, process, the command and control function and facilities, and the coordination with other governmental departments and agencies, with emphasis on the responsiveness to the requirements of the President and the Secretary of Defense.

"(2) The defense research and development efforts from the standpoint of mission fulfillments, costs, organization, time and interrelation with the scientific and industrial community.

"(3) The defense procurement policies and practices, particularly as they relate to costs, time, and quality..."

Besides the report itself, two appendixes of particular relevance to acquisition research are Appendix E, Major Weapons Systems Acquisition Process, and Appendix L, Comparison of DOD, NASA, and AEC Acquisition Processes.

3. Report of the Army Materiel Acquisition Review Committee (AMARC). Army Materiel Review Committee, Department of the Army, Washington, DC 20310, 1 April 1974. LD 31723.

This report is a product of the AMARC, an advisory committee established in December 1973 from representatives outside DOD. "Their effort was specified to include: a. A comprehensive review, analysis, and critique of the Army's materiel acquisition process; b. Recommendations for improvement, with concentration on organization (especially AMC), and procedures."

4. Navy Marine Corps Acquisition Review Committee (NMARC), Volume 1 -- Report. Office of the Secretary of the Navy, Navy Department, Washington, DC 20350, January 1975. LD 33727 A.

The Navy and Marine Corps Acquisition Review Committee (NMARC) was established by the Secretary of the Navy in August 1974 to assess the organization, management, staffing, and procedures used by the Department of the Navy in developing and producing major weapon systems. Volume 1, the main report, contains a summary on conclusions which pinpointed weaknesses in existing Navy practices and recommendations designed to effect major improvements in the Navy acquisition process.

5. Report of the Acquisition Cycle Task Force, 1977 Summer Study. Under Secretary of Defense Research and Engineering, Washington, DC 20301, 15 March 1978. LD 43297 A.

This report of the Defense Science Board Task Force primarily addressed the length of the current acquisition cycle of defense systems. Conclusions reached were that the program birth process has lengthened threefold, discouragement of concurrency has gone to unreasonable limits, and that product improvement has not been adequately considered as an alternative to new development. Eleven recommendations were offered to reduce the length of the acquisition process.

These studies and other acquisition research has emphasized operational effectiveness and management organization. Initiatives have been further augmented and modified as a result of several organizational studies completed since 1977, including the Department Headquarters Study, the National Military Command Study, the Defense Resource Management Study and the Evolution Report on Exercise NIFTY NUGGET. The implementation of the above studies has materially contributed to the DOD's Acquisition efficiency and effectivenss. "1980 DOD management efforts are focused on 1) improving the policy and planning process, 2) the Defense Resources Board (DRB), 3) functional integration, 4) acquisition management, 5) organizational realignments, 6) energy conservation, and 7) cost reduction actions." [1]

THE ENVIRONMENT OF THE POLICY-MAKER

The OSD and Service policy-maker is squarely in the middle of the management process. With ever increasing legislative and Executive requirements, the ground rules are constantly changing. New draft DOD Directive 5000.1 and DOD Instruction 5000.2 encourage innovation by the acquisition manager to use the full range of contracting techniques, shorten the development time by skipping or shortening the acquisition phases, and otherwise tailoring acquisition programs away from the "standard heel-to-toe acquisition process." No longer able to judge a system on an orderly accomplishment of established milestones, the DOD policy-maker must hassle with open ended and ever changing concepts as "how much competition is enough" and "tailored acquisition strategies." Programs, although they really never did, need not fit the DOD acquisition mold. Each program is different. Changes in policy have dramatic impact in areas that are unanticipated.

In the areas of public law, Executive orders, and Office of Manpower and Budget (OMB) circulars and Office of Federal Procurement Policy letters, the OSD and Service Policy-maker also, however, can not "pass the buck" to the DOD manager. The policy-maker must be conversant with national objectives and must interpret these objectives and the DOD mission into clear direction. Additionally, whenever problems become evident, the policy-maker is required to devise short-term, mid-term and long-term solutions realizing the effect of his actions in other acquisition aspects of the problem. The policy-maker soon comes to realize that all acquisition initiatives are not independent variables, but a push at one side of the "acquisition marshmallow" results in push out problems elsewhere.

The effects of acquisition strategies and policy are the results of the natural environment that DOD lives in: Congress and the President, the military-industrial complex, and society as a whole. The need is to understand this environment and the incentives in this environment and methods that have been adopted to cope with the problems of the large and diverse segments within the DOD. The purpose of policy acquisition research is to define acquisition problems, developing a structure for consideration of alternatives and mechanics of solutions, developing checks and balances as a restraint to limit conflict, and utilizing theory and reality to maximize benefits for DOD. The objective of the DOD problem solution is to maximize security of the nation while minimizing the cost to the nation's taxpayers. The basic threats to management independence include the considerable influence of Congress and the President in the setting of laws, policy, and the budget; by other agencies of the government enforcing their authorities on operations within DOD; and by public opinion of unethical practices. As the DOD budget represents a not insignificant portion of the nations Gross National Product (GNP) and a large portion of the budget which is variable in the short term, pressure remains to control the DOD budget.

THE DOD MANAGER

The acquisition function within the DOD involves many functional areas - engineering, production procurement, quality assurance, material management, maintenance management, business/financial management,

test and evaluation, and general management. The acquisition process involves:

- Determination of the requirements to meet the threat or new capabilities.
- Evaluation of alternative means to meet the requirement
- Market survey of potential sources
- Qualification of sources
- Design of the statement of work (SOW) for the Request for Proposal (RFP)
- Negotiating price, terms and conditions
- Monitoring performance and the conducting of normal business relationships with the source, including:

  A. Management of the technical interchange

  B. Audit of Costs

  C. Scheduling and conducting management reviews as called forth in the contract

  D. Quality assurance on source's performance.

  E. Resolution of scheduling problems

  F. Changes in contract scope of work and

  G. Resolution of product quality and service problems

- Establishing acquisition policies, control/ reporting systems and performance - measurement systems.
- Management of inventories of spare parts, materials and supplies.
- Disposal of waste and scrap materials.

An acquisition strategy is a plan of action designed to achieve given goals and objectives. Acquisition strategies often are not clearly understood. Well conceived and skillfully executed acquisition strategies are highly critical to the success of a program. Acquisition stratgies vary greatly from one situation to another because each situation is unique. Every strategy has to be tailored to the product and its industrial base, acquisition history and stage of the acquisition cycle. There needs to be a high degree of interfunctional involvement in decisions on acquisition strategy. Considerations such as competition, the socio-economic programs, technology innovations required, alternative concepts evaluation, prototyping and other policy issues should be addressed in the formulation of the acquisition strategy.

Just as the acquisition players must team together to achieve the proper acquisition strategy and implementation of that strategy, DOD managers must also consider the force mix of equipment to be fielded, quantities and deployment schedules to achieve a synergistic mix of equipment to counter the collective threat.

ACQUISITION RESEARCH COORDINATION AND IMPLEMENTATION

DOD Directive 4105.68 [2] perscribes the policies and procedures to initiate, conduct and coordinate acquisition research. As defined in the directive, an acquisition research element is a "functional or academic organization whose principal function is to collect, review, digest, analyze, appraise, or summarize data or information related to the procurement-acquisition process for the purpose of developing new management concepts and/or more effective business methods for acquiring systems materiel or services or improving the DOD procurement practices." The acquisition research element inputs acquisition research results to the Service staff element involved with the identification and solution of policy and operational problems. It is up to the policy staff to ascertain the utility and desirability of implementing the recommended alternatives. An Acquisition Research Council (ARC) and Acquisition Research Coordinating Council (ARCC) have been established to provide research guidance and coordination. The councils are composed of senior acquisition policy members from OSD, the Services and DLA. Each Service has an acquisition research element responsible for programming, budgeting, funding and other related support for their research efforts.

A Memorandum of Understanding (MOU) has been signed by the heads of the respective acquisition research elements to document the cooperative efforts among the elements. Called the Defense Acquisition Research Element (DARE) working group, the elements are the Research Division of the Defense Systems Management College; the Army Procurement Research Office (APRO) at Ft. Lee, VA; the Office of Naval Research/Navy Center for Acquisition Research, Arlington, VA; and the Air Force Business Research Management Center (AFBRMC), Wright-Patterson AFB, OH, with the Federal Acquisition Institute (FAI) as an ad hoc participant. The DARE working group functions to coordinate acquisition research programs, exchange program information, exchange technical expertise by review and evaluations of proposals, assist in developing joint programs, and disseminating relevant research results within their respective Service and OSD staffs. The DARE working group provides assistance and support of this Annual DOD/FAI Acquisition Research Symposium to exchange results among OSD policy-makers, DOD Acquisition managers, acquisition researchers and industry. Projects with interest to more than one element are considered for cooperative, joint programs in the form of joint funding, follow-on funding by another element to broaden applicability, joint data bases for the lead DARE, and joint service testing of acquisition innovations.

Each research program must identify and document processes and procedures requiring research. Balanced log-range and mid-range improvements in the acquisition techniques, business methods, and/or acquisition cycle are achieved by concentrating on the fundamental causes. Each element maintains

liaison with industry and academia to monitor and collect information on methods research. Prior to implementation, each program should also address the review and testing of the acquisition research tools and recommendations. As part of the implementation, the research program may also include preparation of directives, regulations, instructions, pamphlets or training material. All acquisition research should be registered with DLSIE to inform interested managers and researchers of current research efforts. Figure 1 is the acquisition research process from DOD Directive 4105.68.

MANAGEMENT OF ACQUISITION RESEARCH

Acquisition Research can be related to the same scientific method that acquisition programs are required to follow. A mission need (policy change or identified problem) is documented by the user. The user of acquisition research may be the policy-maker, DOD manager, specific acquisition operating activities, Congressional committees and the General Accounting Office requests, the Acquisition Research Council (ARC) and the Acquisition Research Coordinating Council (ARCC), and contractors and as represented by industrial associations. A significant dialogue is established in the annual DOD Acquisition Conference and this Symposium in establishing research requirements. The Conference and Symposium serve as iterative steps. New policy and problems and their effects are discussed at the Conference. The Symposium presents new tools, techniques and analysis of this new policy and problems and identifies recommended alternatives for resolving these issues. Being six months out of phase (the Conference is normally held in November), a cross-fertilization results between the user and acquisition research elements.

A certain amount of acquisition research is accomplished to develop and maintain an "acquisition technology base." This includes such projects as adaptation of operations research, systems analysis and industrial engineering techniques to the DOD environment; development of industrial data bases for later analysis; documentation of the complex and dynamic acquisition process; and communication of results to the acquisition research practitioner.

The DSMC Five Year Acquisition research Plan includes the following categories of research:

- Development of an acquisition information system.
- Devise acquisition management strategies based on current policies and good management practice.
- Study competition and procurement initiatives.
- Examine project management initiatives.
- Produce guidance for operating in the NATO/RSI environment.
- Analyze cost estimating and control techniques.
- Develop better methods for resource allocation.
- Analyze and establish the impact to current policy and procedures on new management initiatives.
- Examine contractor related initiatives.
- Investigate general management and organizational practices.
- Constitute the decision-making process and analyze the structure for proper decision-making.

To avoid duplication of effort, the DSMC provides the coordination of all Department of Defense acquisition research to include the three Services; likewise, it promotes a continued interface with the Office of Federal Procurement Policy in the Office of Management and Budget, especially the Federal Acquisition Institute. Research efforts are based upon tasking from the Office of the Secretary of Defense; moreover, many are self-generated as a result of policy and emphasis changes. Thus, the college provides an acquisition research capability in support of DOD requirements which is considered to be over and above those accomplished by the Services. DSMC has as its primary acquisition research objective the management and implementation of an integrated, objective program of research that will:

- Influence DOD acquisition policy.
- Anticipate future problems and propose possible alternative solutions and
- Provide research support for the DSMC educational program.

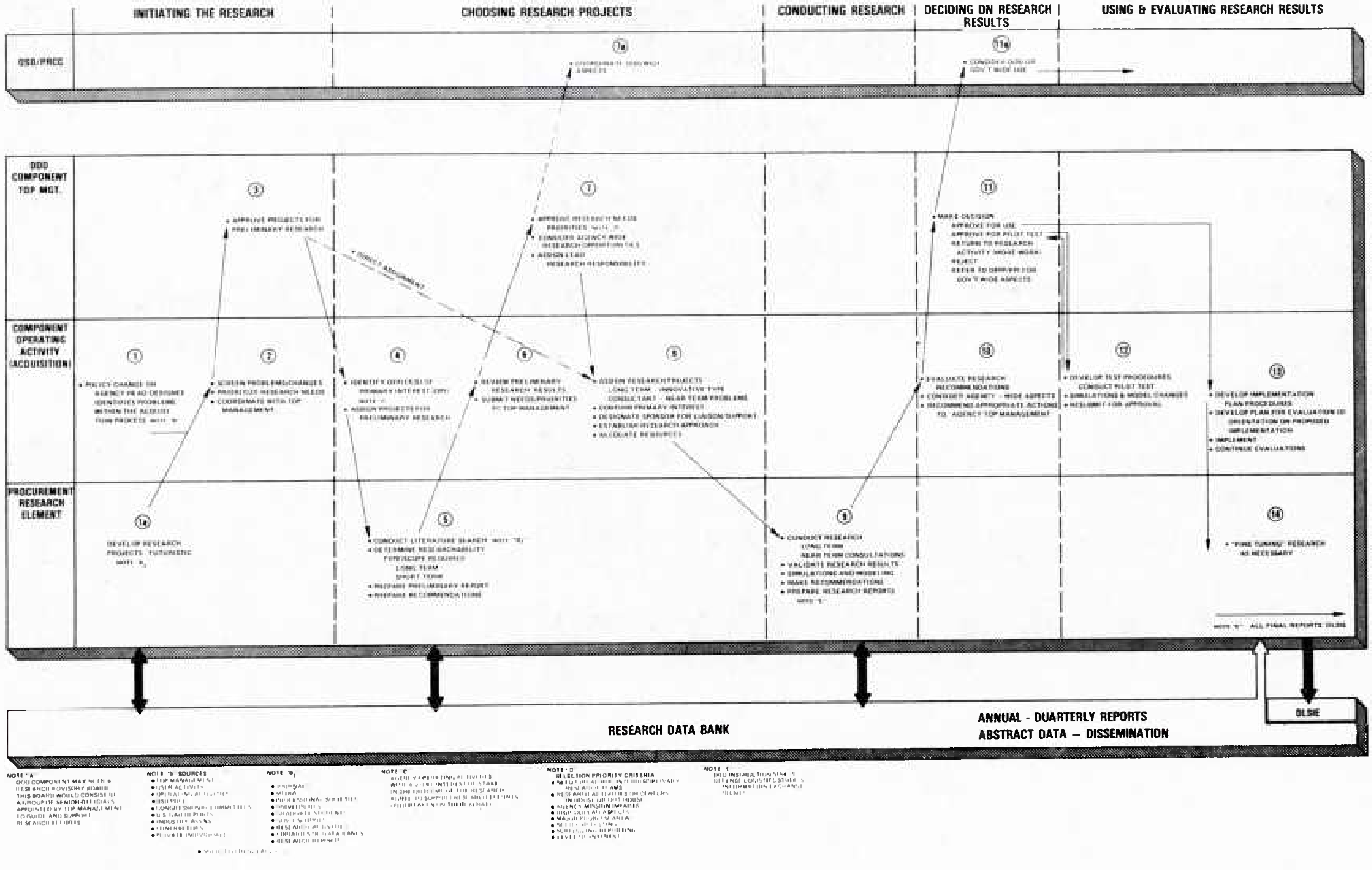
After tasking or approval of acquisition projects, offices of primary interest are identified. A research program management plan is prepared including the scope of work, scheduling requirements and resource requirements. Although Figure 1 shows these steps as separate, the Service and OSD management is involved through continued liaison by the acquisition research element via status updates and reviews. This interface with the acquisition manager and policy-maker is critical to assure that the project is current (that we are not solving yesterday's problems) and that the environment (new policy, legislation, and perspective of the problems) is known.

Several modes for accomplishing research are available to the acquisition research manager. These include:

- Contractual research.
- Faculty/staff of the various DOD institutions involved in acquisition education.
- Workshops and Study Groups.
- Government Agencies outside DOD such as FAI.
- Internal acquisition researchers.

FIGURE 1. ACQUISITION RESEARCH PROCESS

CORRECTING/IMPROVING THE PROCUREMENT PROCESS THROUGH RESEARCH: A SYSTEMATIC APPROACH



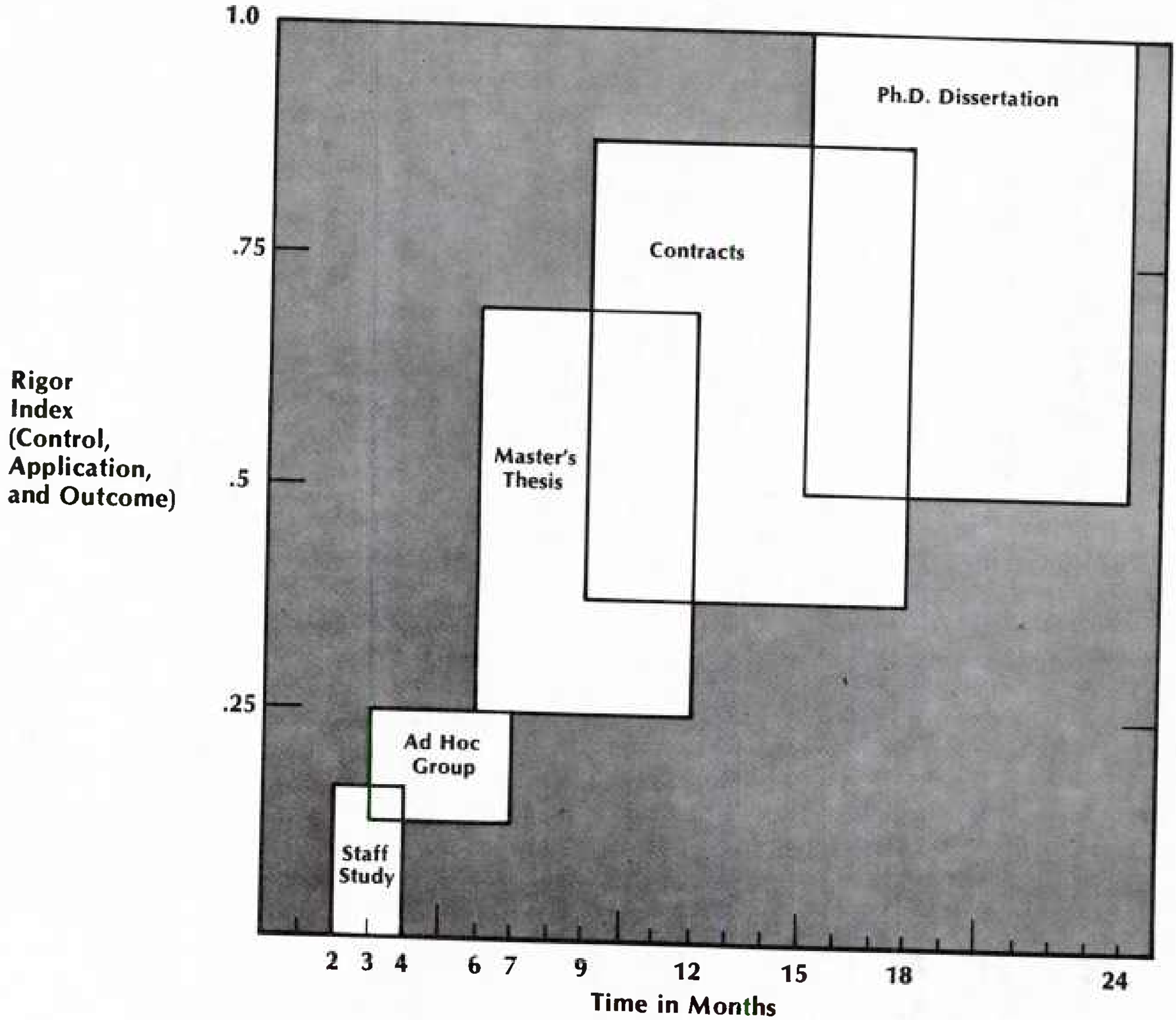


Figure 2 **RESEARCH STUDY SPECTRUM**[3]

- Students at DOD acquisition education institutions (DSMC, NPGS, Command and Staff Colleges, ALMC, AFIT, War Colleges, etc.).

- Contracted university research.

- Graduate students at civilian universities and colleges.

- Reservists on annual tour, on man-days, for points and as a unit project.

Figure 2 illustrates the relative time, effort and rigor of the research results of different modes of research.

The first step in development of a statement of work and actually performing the research is a literature survey. The literature survey includes interviews and reviews of journals, reports and data banks. DLSIE procedures allow for custom bibliographies to be generated for an acquisition research category and topic by the use of a specific DLSIE descriptor. The manager, researcher, sponsor, performer, and a synopsis of the research are displayed in the custom bibliography. Many other sources are listed in the Department of Defense publication A Guide to Resources and Sources of Information for Acquisition Research, January 1980, available from the Army Procurement Office, Ft. Lee, VA 23801.

Acquisition research resources are scarce and calls for these resource substantial, thus requiring that projects be prioritized. A selection priority criteria must consider the requirement for certain types of resources. Graduate students, reservists, and contracted university research are better suited

for theoretical development and/or short range projects while complex acquisition issues require a multidisciplinary team approach. When in-house manpower resources are fully utilized, contractor-conducted research is necessary to increase the capability of the research element and, additionally, a contractor or academic institution may possess expertise and experience in specialized areas not available in-house. DSMC attempts to have a balanced research program using all of the modes listed. Near term problems of the acquisition manager may also require consultant services of the acquisition researcher, requiring flexibility to be built into the schedule. The Services and OSD are responsible for the programming, budgeting, funding, and approval of research priorities based upon the statement of work and preliminary research report (primarily for in-house resources and contracted research efforts) where consideration is given to acquisition mission impact, availability of funds and manpower to support research, major acquisition problems and issues, scheduling requirements, pilot implementation needs and Service and OSD level of interest.

Once approved, the research may be conducted based upon model building and simulations, lessons learned, or other analytical analysis of alternatives. Validation of the research results and coordination of the recommendations with the offices of primary interest is necessary prior to completion of the "for approval" report. The research report must, in addition to receiving approval of the appropriate OSD or Service manager, meet the requirements of DOD Directive 5000.19 entitled "Policies for the Management and Control of Information Requirements" and DOD Directive 5100.62 "Clearance of Research and Studies with Foreign Affairs Implications." The guidelines of DOD Instruction 7041.3 "Economic Analysis and Program Evaluation for Resource Management" are to be followed for economic decision analysis and program evaluation studies. Studies and analysis involving the collection of or access to personal data must be managed in accordance with the provisions of the Privacy Act of 1974 and DOD Directive 5400.11, "Personal Privacy and Rights of Individuals Regarding their Personal Records."

Upon approval of the final report, implementation through pilot tests or changes or additional simulation or models may be required to be resubmitted for approval. The research must be developed through implementation plan procedures which include plans for evaluation. Fine tuning may be required based upon these evaluations.

Final reports are to be placed in DLSIE for dissemination. Studies and analyses used for management purposes in the DOD and transmitted to other Government agencies and the public must adhere to the provisions of DOD Directive 5000.20 "Management and Dissemination of Statistical Information."

WHEN TO USE ACQUISITION RESEARCH

Acquisition research are tools of management as an integral part of the OSD and Service acquisition responsibility. Research should be conducted only when:

- "The subject is topical and relevant and there is a resonable expectation of a significant contribution to decision-making or policy development.

- The effort can be expected to make a significant additional contribution beyond that of current knowledge.

- Formal study is clearly likely to be superior in result to the regular process of decision making or policy development." [4]

The manager is responsible then for monitoring the research program process, inputting new related problems as they occur, evaluating the effectiveness of the overall study effort to include the usefulness and objectivity of the research findings and that the study is responsive and timely and will receive consideration in the decision-making. Often when circumstances such as cost-effectiveness, timeliness, or data not being available, not using acquisition research is warranted. Probability statements based on abstract assumptions which tend to simplify rather than add realism to the problem can be the expected technique rather than absolute, scientific proof. Research which is irrelevant because it attacks the symptoms rather than the root cause also is not useful.

Not all results are for implementation, either. Research may involve diagnostic methods to confirm that a problem exists or predictive models to forecast the probability of future events. Not all research is really applicable to the selected problem because of problems in modeling and other techniques. Research, accomplished properly, properly validated and relevant to the problem being solved, however, still requires that the results be managed by the policy-maker and manager for effective implementation.

A MODEL FOR MANAGEMENT OF ACQUISITION RESEARCH RESULTS

It is useful to classify decisions in the context of acquisition research recommmendations into the following framework (See Figure 3):

- Alternative acquisition process to achieve specified end objectives or one of the alternative end objectives (cost, quality, performance, competition, compatibility, simplicity, safety, level constraints and intangibles)

- Number of end objectives which are involved in the problem set

- Mix of qualitative vs quantitative measurement

- Statistical inference (certainty, risk and uncertainty)

- Number of decision-makers (policy and managers) and implementers

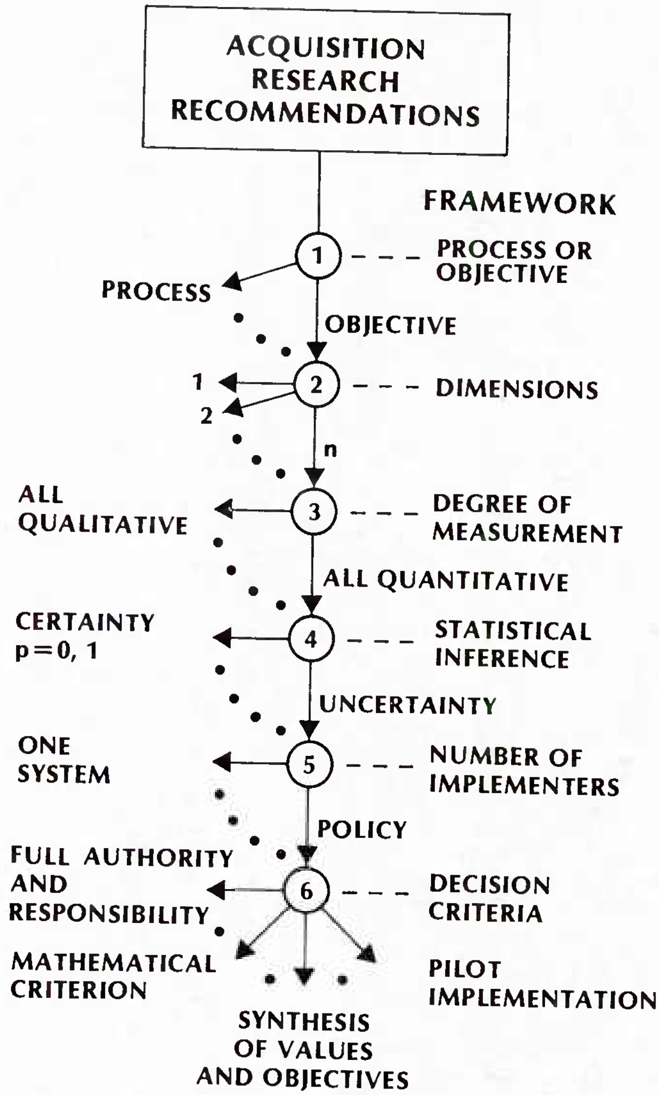


Figure 3 **PARTITIONING OF THE DECISION-MAKING ON ACQUISITION RESEARCH RECOMMENDATIONS**

- Decision criteria (trial implementation, objectives, authority and responsibility, and mathematical criterion).

Acquisition research implementation requires that decisions be made in many of these classes. These six classes together define a very large number of decisions.

The difference between the process and end objectives is fundamental in describing the research process. The process is the not independent of the objectives, but a "means" of achieving some higher objective. Objectives may change based upon alternative processes, and conversely. It is extremely important in acquisition research to list all objectives and to manage the implementation of the results realizing these objectives.

Objectives which are quantitative in one simple function (time, dollars, performance, etc.) are much preferred because the mathematical manipulations with such objective functions is more highly developed. More difficult decision criteria exists when some or all of the objectives can only be stated in qualitative terms such as ethical, social or psychological values. Many acquisition decisions must be made by "weighing" qualitative terms, and therefore are not amenable to exact quantitative solution techniques. Sensitivity analysis provides the technique for evaluating the effect of the weighing factor.

Decisions are made under conditions of certainty, risk and uncertainty in the realm of design of experiments and statistical inference. Mathematical expectations, or some variant, are used for handling

decisions based upon any combination of risk and uncertainty usually utilizing experimental evidence from surveys or running a trial implementation.

Decision making problems increase with the number of individuals or programs involved. The chief problem in dealing with general policy decisions is that of ascertaining the objectives of each group and individuals (key Congressmen, Senators and their staffs, OMB, OFPP and FAI, OSD and the Services) within these groups and then innovating ways of combining these complex objectives for the different individuals.

The types of decision criteria include 1) statistical decision modes, 2) automatic decisions reflecting full responsibility and authority made involuntarily based upon physcological and psychological stimuli limits, 3) trial and error via pilot implementation and 4) ethical decisions based upon the logic and intuition.

The decision-making model illustrated in Figure 3, has several clearly distinguishable parts: (1) a list of objectives, (2) a list of alternatives, (3) methods for predicting the consequences of these alternatives, (4) some method of assigning probabilities (if any) to the consequences, (5) a value system, implicit in the objectives, for attaching values to the consequences, and (6) a decision criterion, included in the value system, which states how to operate upon the other five parts to specify the best alternative. Although this model is a powerful conception, it probably misleads to the extent that it suggests that good decisions are, or ought to be made by using the model usually known as statistical decision theory. Actually, only a very minute number of decisions are made in this way.

MULTIDISCIPLINARY APPROACH TO PROBLEM SOLVING

Some of the important objectives of acquisition research management are:

- Provide management with as much relevant information as possible need to guided and control the acquisition program.

- Formulate long-range plans and objectives as a framework for individual projects.

- Balance the over-all research program to assure progress along all needed lines, at the same time making the best use of the different types of research manpower and resources.

- Develop objectives and plans for individual projects and make them consistent with long-range objectives. Anticipate future needs to be fully prepared when the time comes for action.

- Keep abreast of new fields, ideas, methods and principles to ensure the best and most timely use of new analytic technology.

- Carry out each operation in the most efficient, effective manner possible, recognizing the requirements for detail and accuracy.

Because acquisition research and management is not a policy-making function, the objectives above fit below the general policies of the sponsoring organization. With the objective of the Department of Defense trying to provide for the military security of the nation and functions of acquisition dispersed among hundreds of organizations - then these objectives are approached with only the greatest difficulty.

The use of a temporary mixed team of specialists requires assignment of experts from permanent organizations. Problems, once uncovered, are brought back to the permanent organizations for research. Called the Ad Hoc Committee form of organization, the team and organization dissolve upon completion of the research project. The major limitation to this organizational approach is that these temporary teams rarely document research accomplished in their regular organizations and, therefore, a fund of knowledge that ties together the disciplines is not built up.

The opposite extreme is the department approach, where the organization is divided according to projects. Specialists may be available in reliability and systems design, project administration, operations research and the like. Research may be accomplished primarily for the purpose of conducting research rather than to meet acquisition requirements.

Somewhere between these extremes the matrix management approach welds together the acquisition research team and the operational specialists into a true multidisciplinary approach. This multidisciplinary approach is essential in major studies for the following reasons:

- To be believable to the operator and ultimate user, he must participate and be part of the acquisition research effort so that there is no "black art" in the process

- Both the operator and researcher possess different bents which allow for different "views" of the same alternative and considerations of a full range of alternatives.

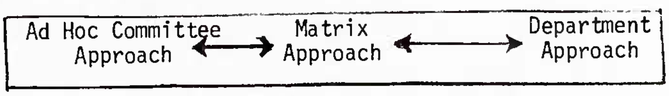


Figure 4. Multidisciplinary Continuum for Acquisition Research

- The operator provides the "realism" while the researcher provides the "what can be" and "what if" to the research effort.

- Too much of the operator involvement can cause the acceptability of the study to diminish, i.e., a frequent excuse used in rejecting a study accomplished by the program office is that it lacks "objectivity."

Therefore, for a study to be successful, the multidisciplinary approach of the researcher, DOD manager and policy-maker is required.

NEW VISTAS IN ACQUISITION RESEARCH

A rather significant partner in the acquisition process is industry. Although industry has and continues to participate when called upon in major acquisition research studies such as those listed early in this paper, the industry and industrial associations also accomplish research to ascertain the effects on industry of new laws, Executive Orders, etc. Most acquisition research fails to take the industrial view into account, requiring the manager and policy-maker to fight those battles with industry. Better use of the industry research capabilities, coordination of DOD research projects of joint interest, and industry participation as a member of the multidisciplinary team is presented here as a challenge to the acquisition research community.

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1. Harold Brown, Report of Secretary of Defense to the Congress on the FY 1981 Budget, FY 1982 Authorization Request and FY 1981 - 1985 Defense Programs, January 29, 1980, p. 282.

2. DOD Directive 4105.68, "Procurement Research," 22 Jun 77.

3. Briefing on the Air Force Business Research Management Center Acquisition Research Mission, 1979, unpublished.

4. DOD Directive 5010.22, "The Management and Conduct of Studies and Analyses," 22 Nov 76.

SESSION 18

PRODUCTION PLANNING AND MANUFACTURING TECHNOLOGY

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IMPROVED ACQUISITION OF MUNITIONS -- TWO YEARS LATER

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ABSTRACT

This paper is written to describe a scheme for the acquisition of non-nuclear munitions. The paper will discuss a study conducted at the Armament Division (previously known as the Armament Development and Test Center) at the request of the Deputy for Armament Systems. The study was chaired by the Deputy Director of Acquisition Management and the author of this paper was a participant in the study effort. Other participants in the study were representatives from contracting, contract pricing, budget office, cost analysis, plans and requirements, manufacturing, and legal. The study resulted in an acquisition approach, not necessarily unique to the acquisition process, but unique to the way munitions are developed, produced and deployed. It represents an advancement in the way the Air Force does its munitions acquisition.

BACKGROUND

It is worthwhile, that a brief history of armament acquisition be noted. In 1968, the Air Force redesignated the Air Proving Ground Center (APGC) to the Armament Development and Test Center (ADTC) and eventually became responsible for the initial acquisition of USAF air deliverable/non-nuclear munitions. With the subsequent assignment of the Armament Laboratory to ADTC, the transition of an item from development to production and deployment became an important concern. Items were being developed in a laboratory environment, and placed into production without the benefits of Full Scale Engineering Development. In 1973, the Deputy for Armament Systems was established to provide a systems approach to weapons acquisitions and a scheme called Pilot Production was introduced.[1] Pilot Production took items that were in development and attempted to productionize the munition. Its objectives were to assure an item could be produced at an affordable cost, provide items for IOT&E which were "representative" of production hardware, and to verify that the technical data package was suitable for competition and fixed price contracts. The Pilot Production technique did help, but did not eliminate the basic problems of inadequate data packages and insufficient demonstration of the manufacturing processes intended to be used during production. The Pilot Production technique resulted in an extension of the acquisition cycle since there was usually a break between Pilot Production and rate production, due to testing and procurement lead time.

THE STUDY

Early in 1977, the Deputy for Armament Systems directed that a study be conducted to find a way to reduce the time required for the full scale development and transition into rate production.[2] The results of the study were constrained by the premises that there would be no degradation of end product, the proposed solution would have an acceptable level of risk, and the practical considerations of present regulations, guidance, existing funds, and personnel. The study assumed that the principal reason for full scale engineering development was to proceed to an economical and efficient production. History has shown that the time span from idea to first delivery was taking as long as 13 years. The study concluded that six primary areas needed improvement. They were as follows:

a. Nondefinitized User Requirements. In the past, the user did not clearly define his requirements. This uncertainty permeated technical parameters, quantity, and schedule. Often as the item progressed through development, the user technical requirements changed, the quantities changed drastically, and need dates were revised.

b. Production Engineering. In the press for technical excellence, the developer often overlooks the necessity of designing for production. Often there is little or no interface between development (design) engineering and production engineering. Thus, the item often has to be redesigned so that it can be manufactured in a volume production environment.

c. Manufacturing Process Change. In the past, the Armament Division has experienced much difficulty with the changes in manufacturing processes following entry into production. As rate manufacturing process changes were implemented, numerous test failures were experienced in the First Article Acceptance Test (FAAT) of production items. The baseline established at the Critical Design Review (CDR) in Full Scale Engineering Development (FSED) and tested in small quantities often had to be changed to adapt for high rate manufacturing processes.

d. Data Packages. The technical data packages resulting from Full Scale Engineering Development were often inadequate to provide for any competitive follow-on procurements. A method was needed to validate or "proof" the data package in a

production environment, insuring that tooling, processes, material, and production planning were demonstrated.

e. Overall Procurement Strategy. At the start of Full Scale Engineering Development, the concern often was the development of the item. Very little thought was given to the production phase. Technical achievement was foremost, as the attitude prevalent at that time was "we'll cross that (Production Phase) bridge later" since the requirement will change and the strategy for production will be based on the available production funds at the conclusion of Full Scale Engineering Development. Consequently, industry was first dedicated to developing a technically feasible article and then later consider the changes necessary for producing an article in large numbers.

f. Funding. Budgeting and funding of munitions programs has historically been inadequate. Programs often had to be developed within existing budget constraints. The attitude of "I know you need 'X' number of dollars, but you must give me a 'Y' number of dollars program." Consequently, the program office has had to "make do" with the funds which can be made available.

g. Secondary Areas of Improvement. The study also showed some additional areas of needed improvement. It recognized the need to staff the manufacturing directorate (as the organization was only 54% manned), technical expertise was needed on a consultant basis and an increase in the overall awareness to the overall acquisition process was needed.

IMPLEMENTATION OF CORRECTIVE ACTION

Shortly after conclusion of the study, the Armament Division began implementing corrective action. Many of these items were within the capabilities of the Armament Division, while some required the support of the user and higher headquarters. Implementation took many forms:

a. Nondefinitized User Requirements. The user and the requirements planner now takes an active part in the acquisition. His desires are documented in the Mission Element Need Statement (MENS) and the eventual Program Management Directive (PMD). Requirements are justified as are any changes. Priorities are established and are considered baseline throughout the life of the acquisition. Projected numerical requirements are outlined. The user's requirements are questioned and challenged in Business Strategy Panels and the user is often an active participant in the source selection. The user participates in program status reviews and is active in the test phases of the program. Changes are challenged and require strong justification.

b. Production Engineering. Statements of Work (SOWs) for production engineering have been developed and institutionalized. Separate line items are included in the contract so that budgeting and funding can be defined and tracked. Specific language is written into the contract to insure interface between the development and manufacturing engineers. The contractor is required by the SOW to identify his proposed manufacturing process changes by the Preliminary Design Review. He is required to conduct trade studies outlining the most economical method of tooling, material, processes, facilities, etc. He reports these efforts at scheduled design reviews. After Critical Design Review, changes can only be implemented due to safety considerations, test failures, or significant cost savings. The contractor is also required to develop a producibility plan, documenting his relationship of design to the most effective and economic means of fabrication, assembly, inspection, test, installation, checkout, and acceptance. Following CDR, all hardware is built with the processes and material to be used in rate production.[3]

d. Data Packages. Inherent in competitive procurements is the validated Technical Data Package (TDP). The design now truly frozen at CDR, and the processes and material established during FSED, are then translated into the TDP and validated by the developer in a Low Rate Initial Production (LRIP) environment. The LRIP process is the initial phase of an approved production program which requires the contractor to demonstrate the manufacturing process and to provide items for First Article Acceptance Testing. It is a "low rate of output at the beginning of production to reduce the Government's expense for large retrofit problems, while still providing adequate numbers of production items for final development and operational test prior to full scale production decision." This process considers that the developer is also the low rate producer.[4] Competition is introduced following validation of the data package and/or through the "leader-follower" concept.

e. Overall Procurement Strategy. At the start of a program, it is inherent to realize that the purpose of FSED is to not only develop a technically sufficient item, but to insure ease of production. At the local Business Strategy Panels, the program office must now consider not only how the FSED phase will be accomplished, but also must discuss how the program will transition to production. Thought must be given to show the entire acquisition strategy for both development and production.[5]

f. Funding. In the past, budgetary and funding for front loading of production engineering, production line planning, etc., was limited or nonexistent. The program manager is now expected to cost programs realistically and to establish realistic cost standards and force compliance. Independent Schedule Assessments and Independent Cost Estimates are often accomplished prior to project initiation.[6] The trend for low estimates for getting the program started and then "getting well" in production has diminished.

g. Secondary Areas of Improvement. It took a long time to hire a manufacturing consultant.

Detailed justification to comply with civilian personnel regulations and procedures, and the search for talent has been satisfied. The Directorate of Manufacturing and Quality Assurance has approached full staffing and two Production Engineering Service Officer positions have been added and filled. "Business Management" philosophy has been institutionalized and is effective.

THE RESULTS

Many of the recommendations of the study have been implemented. Requirements are better defined, coordinated, and projected. Work is still required to insure that priorities are baselined and maintained. The concept of early involvement of manufacturing engineering and process control have been institutionalized and implemented. The procedures have met with a varied degree of success tending towards the recognition of transition to production. The concept of TDP validation is yet to be tested, but should be known in three programs presently in FSED. Corporate and acquisition planning for the entire cycle is demanded, and with some frustrations being experienced. The biggest hurdle to overcome is that of budgeting. It is very difficult to overcome the "don't ask for production funds until you have proven the items in development" syndrome. Although this activity is within the existing guidance and regulations, it is difficult to convince the budget planners to obligate some production funds while the item is still in development.[7] This hurdle is being overcome, primarily because it is being driven by the need of an item in the inventory. On one program, we will be using a small amount of production funds, during development, to begin acquisition of the production line. We are working very hard so that budgeteers won't say "I told you so." Overall results to date are encouraging and indicate a definite advancement in Air Force munitions acquisition.

FOOTNOTES

1. Briefing, Pilot Production, June 1972.

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4. Paper, "Low Rate Initial Production," May 1977.

5. AFSC Regulation 70-2, "Business Strategy Panel."

6. AFSCR 800-35, "Independent Schedule Assessment."

7. DODD 5000.34, "Defense Production Management."

PRODUCTION READINESS - THE FIRST YEAR IN REVIEW

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ABSTRACT

The Department of Defense issued Instruction DODI 5000.38, 24 January, 1979, which is the latest in the series stemming from the basic policy and responsibilities set forth in Department of Defense Directives 5000.1 and 5000.2. This instruction required Contractor Production Readiness Reviews prior to DSARC III. Technology advances, in both the private sector and the defense industry, have placed this area in the current spotlight. On the other hand, the machinery, mainly skilled manpower, necessary to adequately execute specific remedies is being demanded at a time when DOD manpower resources for acquisition management have been reduced beyond prudent levels. Service Implementation via Army Regulation 70-67, Air Force Systems Command 84-2 and Secretary of the Navy Instruction 4801.1 are, on the surface different, but are surprisingly common in most aspects. In addition to a review of the paperwork implementation, the first year has provided selected experiences. This research concludes there is a need for an all encompassing policy covering program and contractor reviews.

PRODUCTION READINESS REVIEWS

The Department of Defense issued instruction DODI 5000.38, 24 January 1979, which is the latest in the series stemming from the basic policy and responsibilities set forth in Department of Defense Directives 5000.1 and 5000.2. This new instruction is directed at one of the last manageable casual inhibitors to a successful hardware program, which is absent or ineffective production planning. This research reviewed 27 major weapon systems which were involved in DSARC decision processes. As a result of this review, it was evident that production problems are inhibiting major weapon system acquisitions. Telephonic interviews with individuals knowledgeable concerning production in the seven (7) Army, seven (7) Air Force, and thirteen (13) Navy programs revealed that almost all of the programs which have been subject to DSARC III approval since 1975 have experienced production problems. The following table depicts the statistical information from this research:

TABLE I

SERVICE	TOTAL	PDN PROB	NO PDN PROB	NO INFO
Army	7	5	1	1
Air Force	7	1	5	1
Navy	13	7	0	6
	27	13	6	8

Some of these system situations are prologue for a future research effort to compare systems subject to DSARC III after DODI 5000.38 to see if the Production Readiness Review (PRR) improve the production aspect of the major weapon system program. Thus, with regard to the identification that a basic policy was necessary to address or reduce production risk considerations, and permit the evaluation to the production problems prior to approval of the system for production at DSACR III, a policy requirement like DODI 5000.38 was necessary.

INITIAL PRODUCTION PROBLEMS - NOT NEW

Initial production problems are inherent in any new manufacturing effort. While it is not always a consensus on how to deal with initial production problems, the area of initial production problems is well defined with regard to major defense productions and the private sector activities as well. With respect to the key ingredients in translating a product from development product design, production design, and process planning are common activities. (1:262) In addition, most of the preliminary work essential to orderly transition to production is performed by process engineers and industrial engineers. (2:132) In one Navy system subject to DSARC III, the competing of components of the system resulted in small business sources as a supplier who in turn lacked the necessary level of process engineering to take the in-house design to production.

Less the reader of this research falsely conclude that the contractor effort to prepare for transition to production is an easy task or that the PRR is, in itself, not all that complicated review, one might develop a better understanding of the basic problem of going from research to production by reading two selected readings. (3:157-170)

INITIAL PRODUCTION PROBLEMS INCREASING

Contributors to the difficulties involved with initial production are by no means finite. Since major weapon system development is in most cases a direct attempt at replacing old technology with new, technological advances contribute more significantly to initial production problems in defense material than in the private sector. However, in attempts to beat competition by capturing the latest technology, the private sector does experience, to some extent, many of the same problems faced by Department of Defense material producers. (4:88) Fortunately, in our era we are able to cope with the problems and risks of new technology as our knowledge of production management as an applied science is growing exponentally. (5:15, 16)

POLICY GUIDANCE - GENERAL

An examination of the Army, Navy, and Air Force policy and procedural guidance reveal a very common thread associated with implementing the new DODI 5000.38. The Air Force document addressing this subject is the Air Force System Command 84-2, and has been in existence almost ten (10) years. While it is a more detailed document, it does not necessarily contain significantly different information from the more recent services implementation such as the section of the Navy Instruction 4801.1, and the Army's Regulation 70-67. For instance, the review chief is covered by the three services as follows:

POLICY GUIDANCE - REVIEW CHIEF

ARMY

"The organization of the review team will provide for a senior Army officer or civilian equivalent, selected by the PM, to serve as the chairperson. The chairperson will determine the team membership, organize and manage the team effort and supervise preparation of the findings." (6:10)

AIR FORCE

"The team director, selected by the program manager, will be a senior Air Force officer or civilian equivalent. He will select, organize and manage team efforts, brief program managers and contractors, supervise report preparation, and report to the program manager on progress and final status of the review." (7:3)

NAVY

"The PRR team leader will serve as director and focal point for the PRR effort. Under general direction of the project manager, he will coordinate the selections for team membership, organize, schedule and manage the team efforts, and supervise the preparation of objective findings." (8:5)

POLICY GUIDANCE - REVIEW AREAS

In addition, areas to be covered by the review are addressed by the services as follows:

ARMY

Production Design (7)

Industrial Resources (2)

Production Engineering and Planning (10)

Materials and Purchased Parts (9)

Quality Assurance (4)

Logistics (8)

Contract Administration (5) (6: APP A 1-7)

AIR FORCE

Engineering/Production Design (24)

Manufacturing Planning (16)

Production or Manufacturing Operations (21)

Production/Manufacturing Methods and Processes (17)

Tooling and Test Equipment (10) (7:10-12)

Shown in parasynthesis are the number of sub-issues specifically addressed for review.

POLICY GUIDANCE - TEAM

The team composition is set forth in broad general terms as follows:

ARMY

"The team will consist of persons having industrial and production training and experience. It will include representatives of all areas affecting the development/production decision, e.g., producibility, configuration management, engineering development, program management, maintenance management, and qualilty assurance. Review personnel will have the training and experience to analyze program plans and accomplishments in enough depth to objectively judge production readiness and related risks. (6:10)

There has been some effort to provide more of a pamphlet type guidance to individuals responsible for executing the Production Readiness Reviews. An example of this type document is the Army's Pamphlet, Production Readiness Review Plan, prepared by the US Army Aviation Research and Development Command, St. Louis, MO. (9:NA)

AIR FORCE

"Team size and composition will be determined based on scope and depth of the review effort." (7:3)

NAVY

"The PRR team shall consist of individuals having requisite technical, industrial and production training and experience which qualifies them to probe program accomplishments, preparations and plans in sufficient depth to make objective judgements of production readiness and attendant risks. The PRR team will be augmented as needed by part-time consultants where specific expertise is required." (8:5)

EXECUTION OF THE ASSIGNMENT

During research for this paper a questionaire was sent to selected major weapon system project offices. This inquiry was an attempt to cover Army, Navy, and Air Force programs in a broad fashion in an effort to determine how the Production Readiness Reviews were staffed and the sizes of the staff that was used. The following table shows that, as a result of this area of research, the size of the team varied significantly but that the average team was approximately 20 people. The assignment of part-time personnel and consultants made it impossible to do a statistical analysis, and the data gathered from the questionaire can only be subjectively reviewed.

TABLE 2

PRODUCTION READINESS REVIEW-TEAM

TEAM SIZE	11 - 42
TEAM SIZE (AVERAGE)	22
TEAM COMPOSITION	
INDUSTRIAL ENGINEERS	24%
OTHER PRODUCTION ENGINEERS	24%
OTHER INDUSTRIAL	17%
ALL OTHERS	35%
	100%

From the above table it is apparent that industrial engineers and engineers with industrial skills/experience are the primary individual in demand for the Production Readiness Reviews. To a lesser extent non-degreed individuals mainly found in the procurement GS-1150 Industrial Specialist series were represented. Many other skills and disciplines are needed to cover the complete requirement of the production readiness review.

SKILL/MANPOWER NEEDED

In reviewing the first year of effort under the new DOD policy, it is apparent that this attempt to make information concerning still another consideration, available at DSARC III, has demanded additional man power, or a diversion of manpower to the production readiness review requirement. Thus, in an era where affordability as it relates to the total services budget and the DOD budget are a key consideration, less skill manpower is available to investigate the merits and risks associated with the candidates on which pro duction decision are to be made. In this production readiness review research, it was apparent, for instance, that industrial engineering and other engineering skills are also in demand by the private sector. Thus, they are in short supply in both the number and the quality necessary for Defense Contractors and DOD team reviewers. This conclusion is developed from the results of a research questionaire to selected schools with industrial engineering programs. A similar request to the Department of Labor is expected to confirm the situation in the already employed work force, although the reply was not received in time to be included in this paper.

As information provided from the Department of Defense Production Engineering Serivces Offices input to this research carefully pointed out, the production readiness review should also assess in balance the issues associated with related cost, performance, and reliability. However, this consideration of the total production readiness surfaces the issue of compatibility of the DODI 5000.38 with the other areas of DOD guidance.

PUTTING IT ALL TOGETHER

There are several areas which seem to have somewhat overlapping responsibilities with the requirements of DODI 5000.38. These areas are:

a. Design-to-Cost.

b. Should Cost.

c. Contractor Procurement System Review.

d. Determination of Contractor Responsibility.

e. Producibility, Engineering, and Planning.

It can be seen from some of the basic policy guidances that the overlapping exists. For instance, in the DOD policy on Design-to-Cost the objective of the policy is stated as follows:

DESIGN-TO-COST

The objective of Design-to-Cost, as stated in DODI 5000.28, is twofold:

A. To establish cost as a parameter equal in importance with technical requirements and schedules throughout the design, development, production, and operation of weapon systems, subsystems and components.

B. To establish cost elements as management goals for acquisition managers and contractors to achieve the best balance between life cycle cost, acceptable performance and schedule. (10:2)

SHOULD COST

The comprehensive effort in a Should Cost Review also is directed at much of the same area of responsibility. The Should Cost purpose as stated in the Army Pamphlet AMCP 715-7 is:

"The term Should-Cost describes an approach to cost analysis through fully coordinated efforts of a team of Government specialists in engineering, pricing, audit, procurement, and management. The specialists review in detail the contractor's engineering and manufacturing operations, accounting procedures, cost estimating systems, purchasing procedures, make-or-buy decisions, organizational structure, and any other element of cost and management control required for contract performance. The analysis is used to identify uneconomical or inefficient practices in the contractor's operation, and to formulate the Government's negotiation position, on the basis of the team's estimate of what the contract should cost to perform, based on reasonably achievable economies and efficiencies." (11:1-1, 1-2)

CONTRACTOR PROCUREMENT SYSTEM REVIEWS

The requirement for Contractor Procurement System Reviews, as contained in the Defense Acquisition Regulation 1-406 (c)xii is stated as follows:

"Review, approve or disapprove and maintain surveillance of the contractor procurement system." (12:1:80) The purpose of this review is covered in Armed Services Procurement Regulation Supplement No. 1 Guide for conducting Contractor Procurement System Reviews (CPSRs) which states:

"While the prime contractor has the responsibility of managing his procurement program, the contracting officer is responsible for evaluating the contractor's procurement system to assure that it is efficient and effective in the expenditure of Government funds. The Contractor Procurement System Review (CPSR) is designed to assist contracting officers and contractors effectively to perform their obligations, including the granting or withholding of approval of a contractor's procurement system."(13: S1:1)

DETERMINATION OF CONTRACTOR RESPONSIBILITY

The requirement on determination of contractor responsibility, as contained in Defense Acquisition Regulation 1-903 is stated as follows:

In the review to determine contractor responsibility a prospective contractor must:

"(i) have adequate financial resources, or the ability to obtain such resources as required during performance of the contract (see Defense Contracting Financing Regulations, Part 2, Appendix E, and any amendments thereto, see also 1-904.2 and 1-905.2; for SBA certificates of competency, see 1-705.4);

(ii) be able to comply with the required or proposed delivery or performance schedule, taking into consideration all existing business commitments, commercial as well as governmental (for SBA certificates of competency, see 1-705.4);

(iii) have a satisfactory record of performance contractors who are seriously deficient in current contract performance, when the number of contracts and the extent of deficiency of each are considered, shall, in the absence of evidence to the contrary or circumstances properly beyond the control of the contractor, be presumed to be unable to meet this requirement). Past unsatisfactory performance, due to failure to apply necessary tenacity or perseverance to do an acceptable job, shall be sufficient to justify a finding of nonresponsibility. (In the case of small business concerns, see 1-705.4 and 1-905.2);

(iv) have a satisfactory record of integrity (In the case of a small business concern, see 1-705.4); and

(v) be otherwise qualified and eligible to receive an award under applicable laws and regulations, e.g., Section XII, Part 8." (12: 1:159-1:160)

In addition, this research reveals that the determination of Contractor Responsibility and its accompanying field Pre-Award Survey somewhat over laps the responsibility to the DODI 5000.38, and one response to the questionnaire cited the Pre-Award Survey as a substitute for a production readiness review.

PRODUCIBILITY, ENGINEERING, AND PLANNING

The DOD policy on engineering, producibility, and planning has been tied to the Design-to-Cost issue and, therefore, relates to the PRR. Another research effort stated "within the last few years the idea of producibility has become increasingly important. It is viewed as a means to combat the ever increasing cost of acquiring new weapon systems; another factor promoting producibility in the advent of the Design-to-Cost concept within DOD. This will place added emphasis on producibility for some time in the future. (14:25)

All these review/readiness requirements need to be compared to the objective and scope of a PRR as contained in DODI 5000.38 which is: "The objective of a PRR is to verify that the production design, planning, and associated preparations for a system have progressed to the point where a production commitment can be made without incurring unacceptable risks of breaching thresholds of schedule, performance, cost, or other established criteria.

The PRR encompasses all considerations which relate to the completeness and producibility of the production design, and to the managerial and physical preparations necessary for initiating and sustaining a viable production effort.

Finally, it would appear that efforts at providing funding to assure early production planning is accomplished, needs to be definitely integrated into the effort of the initial production readiness reivew. The producibility, engineering, and planning efforts should be the starting point for contractor progress toward accomplishing all of the requirements and assessing all of the risks which are considered in production readiness reviews. It seems appropriate that producibility, engineering, and planning efforts require a continuing monitorship as opposed to a fixed time influence of a Production Readiness Review. However, the nature of the review demands the need for a start date much earlier than four (4) months prior to the DSARC III decision. Previous research effort has identified the relationship of PEP to the DSARC III decision (14:34, 35). Of course, prudent service management has developed advanced reviews of contractors with respect to their production capability and have, in the case of the Army, even codefied these advance reviews in what the Army calls Initial Production Readiness Reviews (IPRRs).

SPECIFIC EFFORTS

The initial Production Readiness Reviews used in this research were those being executed for Army Aviation by the researcher's Command. Although the broad review of this research addressed production readiness reviews of all services, the more indepth research of the first year was associated with Army Aviation in particular.

There seems to be certain underlying needs in conducting Production Readiness Reviews. Significant among the considerations in preparing to conduct the review was the concern, expressed by the Advanced Attack Helicopter (AAH)'s Mr. Anthony Piazza, that the review be independent and also take advantage of corporate memory. The questionnaire did reveal an effort to have the review independent. In attempts to assure the review was not just an extension of the program management office's total program management, an independent director for Production Readiness Review was often appointed. Also, he independently executed staffing responsibility often drawing heavily on resources not from the project office itself, although there was an integration where appropriate, of project personnel to provide the corporate memory aspect of the team's capability.

In other areas, structures seemed to be developed in the first year of Production Readiness Reviews which established teams and subteams reporting to the director. Such a structure was used by Army Aviation personnel in their review, and they classified and prime contractor and subcontractor into requiring either an A, B, or C team. These teams were established based on the initial review of the extent of the particular prime or subcontractor's potential problems and/or the critical nature of an individuals participation. In this concept the Level A team included full coverage for production, technical, logistics, management, and contracts. A Level B team included only production, technical, management, and contracts while the Level C team covered only technical and production aspects in staffing. This type of organizational structure, together with a better coordinated review plan, seems to offer a solution to the problem identified early in this research; that of our limited DOD manpower resources.

COORDINATED REVIEWS

Of course, the overlapping between Department of Defense Instructions and the Defense Acquisition Regulation is not unusual since the DODI policy have their origin with major weapon system acquisition and management, while contracting and purchasing activities are covered by the Defense Acquisition Regulation. It is concluded that this type of overlapping of certain production readiness responsibility seems to occur with respect to the Contractor Procurement System Reviews conducted on a contractor bi-annually as required by DAR 1-406, and determination of contractor responsibilities DAR 1-901 and 1-902.

Within the Army there exists a DARCOM Logistics Status Review (LSR) program which contains an overlapping of the IPRR and PRR logistics area review responsibilities.

CONCLUSION

So it is the conclusion of this research that the DODI 5000.38 need address the existance of concurrent effort and data from Should Cost, Design-to-Cost, determination of contractor responsibility and producibility engineering and planning efforts. Also the issuance of the DODI may now overlap service programs such as the Army's Logistics Status Review. So the services need to reexamine their programs that are related to contractor reviews and program reviews to identify overlapping policy and efforts. The conclusion of this research is that the Deputy Under Secretary of Defense for Research and Engineering (Acquisition Policy) should examine the feasibility of developing one DOD instruction which deals with the entire subject of major weapon system contractor reviews. By capturing all reviews, the present overlapping evident from this research can be eliminated, at least with respect to the DOD policy. In addition, efforts should be made with the Defense Acquisition Regulation Committee to adjust the DAR language to accommodate the use of DOD review information for contracting purposes such as the determination of contractor responsibility. Finally, the consolidated DOD review requirements for major weapon systems will permit the services to re-examine their overlapping requirements to assure that within a service additional overlapping does not

exist. The net result of this action will permit defense contractors to examine the precise reviews that are expected during milestone 0, I, and II. By knowing the exact reviews, they can better forecast their cost and be more efficient in responding to the Government's requirement. Finally, the scrarce technical Government resources that are necessary in order to conduct the review will be more efficiently utilized if a consolidated review requirement is established.

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MANUFACTURING TECHNOLOGY INVESTMENT STRATEGY

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ABSTRACT

Headquarters Air Force Systems Command is developing approaches to enhance the productivity of the defense contractors' industrial base. The Manufacturing Technology Investment Strategy Task Force, nicknamed HAVE PAYOFF '80, is developing a cohesive strategy and implementation plan to blend contractual, manufacturing technology, and capital investment initiatives which directly complement the ability of the Air Force to meet increased military production demands. Emphasis is placed on maximizing the effectiveness of the Air Force Manufacturing Technology (MANTECH) Program as a cost reduction and productivity enhancement technique and establishing technology modernization programs with defense contractors and Air Force Logistics Centers.

PROBLEM

The United States productivity growth rate, the average annual percent rate of change of output per hour input, for all industries, trails the rest of the industrialized world according to Bureau of Labor Statistics for 1970 through 1978.

Table 1. Productivity — All Industries

COUNTRY	RATE OF GROWTH (Percent)
United States	1.8
Canada	3.6
Italy	4.8
France	5.1
Germany	5.6
Japan	9.0

Independent studies by the Department of Commerce (DOC) and National Council on Productivity (NCOP) have shown that capital and technology can account for approximately 80 percent of the rate of productivity growth.

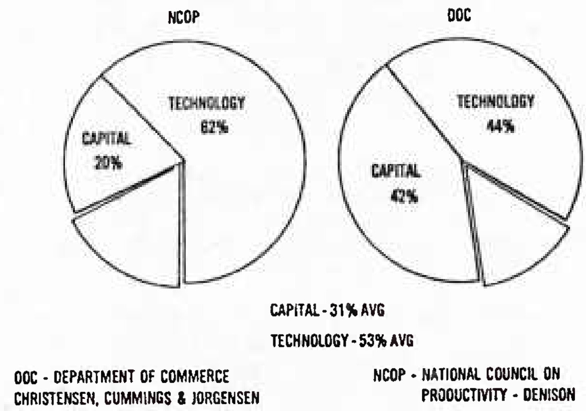

Figure 1. Contributions to Productivity Increases

Nations with the highest ratios of investment to Gross National Product (GNP) had the highest rate of productivity growth. The United States is last of the industrialized nations for manufacturing according to Bureau of Labor and Organization for Economic Cooperation and Development data for 1970 through 1976.

Table 2. Ratio of Investment to GNP for Manufacturing

COUNTRY	FIXED INVESTMENT RATIO	AVERAGE ANNUAL INCREASE IN PRODUCTIVITY (Percent)
United States	14.2	2.3
Canada	21.6	3.2
Germany	26.2	5.9
Japan	31.3	9.0

The U.S. Council of Economic Advisors has predicted that at current productivity growth rates four international competitors will overtake the United States in production per employee between 1985 and 1990.

Table 3. Productivity Projections

COUNTRY	PROJECTED GROWTH RATE (Percent)	YEAR OF OVERTAKE
United States	1.5	-
Canada	2.2	1990
France	3.8	1986
Germany	4.0	1987
Japan	6.3	1988

Mr. Willard Butcher, President and Chief Executive Officer, Chase Manhattan Corporation, stated in his December, 1979, article for the Industrial Engineering magazine, "If immediate action is not taken to reverse the decline in productivity growth, the United States will become a second-rate industrial power." The implication is, of course, that if the U.S. continues the current trend, it cannot remain a first-rate military power.

Growing material, energy, direct labor, and overhead costs threaten the ability of the Air Force to develop and deploy the successive generations of qualitatively superior systems needed to fulfill its mission.

Increasing poductivity, getting more output for the same input, directly increases the responsiveness of the industrial base to Air Force requirements. Increased productivity reduces the amount of labor and materiel required to produce a given level of output, which results in reduced costs and lead times for system acquisitions. Applying advanced manufacturing technology on the plant floor through capital investments by our Aerospace contractors will increase productivity and reduce system acquisition costs and lead times.

BACKGROUND

The Department of Defense has long recognized that capital investments in modern production facilities and equipment can increase productivity and lower systems costs. Defense contractor capital investment, however, has been discouraged by the higher profit potential in commercial markets and by DOD contracting policies. Former Deputy Secretary of Defense Clements recognized that the facilities and equipment used by DOD contractors were growing progressively obsolete. This prompted him to initiate the DOD Profit '76 Study. The objective of Profit '76 was to examine and modify DOD profit policies so that contractors would be motivated to use more capital for reinvestment in modern facilities and equipment.

One of the findings of the study was that Aerospace contractors have typically reinvested less than half the amount reinvested by their nondefense counterparts in facilities and equipment. This finding led to profit policy recommendations and Defense Acquisition Regulation (DAR) changes which provided contractors improved financial incentives for making investments in plant modernization. Implementation of these changes included special capital equipment termination protection, imputed cost of interest on capital investment, increased percentage of profit for capital investments, complementary investment and shared savings.

Air Force Systems Command (AFSC) has recently adopted new contracting initiatives patterned after commercial practices. These initiatives are designed to remove many of the impediments to capital investment. Increasing competition, using more firm fixed priced contracts, employing past performance as a source selection criterion, and multi-year contracts provide opportunities for higher contractor profits. In addition, these initiatives motivate contractors to be more concerned with production efficiency and equipment modernization.

The thrust of the mid 70's was on profit policies and contracting methods which focused primarily on stimulation of capital investment. The DOC and NCOP studies mentioned earlier have shown that new technology, in addition to capital investment, is required to reduce systems cost and increase productivity. The Department of Defense has realized significant cost reduction through establishing advanced manufacturing technology and implementing the technology into the defense industrial base. The Air Force MANTECH program has established sophisticated manufacturing technologies, such as numerical controlled machine tools, laser welding, superplastic forming and diffusion bonding. However, the full payoff from these techniques has not been realized due to the slow rate of adoption by industry.

The purpose of the Manufacturing Technology Investment Strategy Task Force is to develop a cohesive strategy and implementation plan to enhance productivity of AFSC contractors' industrial base. Emphasis is placed on maximizing the effectiveness of the Air Force Manufacturing Technology Program as a cost reduction and productivity enhancement technique. In other words, the HAVE PAYOFF '80 Task Force picks up from the PROFIT '76 effort and addresses the technology and modernization issues of the defense industrial base.

The potential for substantial payoff from capital investment and advanced manufacturing techniques was recognized by the F-16 System Program Director. The Program Office used many of the Profit '76 capital investment incentives and MANTECH project results to modernize the F-16 production line. The savings, after implementation costs, from the F-16 Technology Modernization Program are expected to exceed \$200 million for a buy of 1158 aircraft. The principal elements of F-16 Technology Modernization are: (1) Complementary investments by the Air Force and the contractor (\$25M AF technology investment and \$100M contractor capital investment, (2) termination protection for contractor capital investment, (3) award fees, and (4) shared savings.

Using the F-16 experience as a basis, our goal is to maximize cost reduction resulting from the rapid and widespread application of advanced manufacturing technologies. Consequently, the main emphasis of this effort will be to match manufacturing technical opportunities with current and future weapon systems production requirements. The essence will be an overall technical, business and application strategy to promote rapid introduction of new production technology into the Air Force and Contractor plants.

SCOPE

General Slay, AFSC Commander, chartered the HAVE PAYOFF '80 Task Force with eight specific objectives. The objectives were organized into the following three fundamental areas for primary attention: (1) Identify and provide supporting rational for areas of major MANTECH investment based on significant, generic technological opportunities; (2) identify opportunities for and barriers to the application of new and off-the-shelf manufacturing technologies for production needs, and (3) develop contractual language and improved methods for implementing, tracking and marketing results derived from MANTECH investments.

This regrouping of the objectives will also enable the Task Force to focus on specific segments concerned with systems acquisition: (1) Technology Base, (2) System Program Offices, and (3) Contractors. Pertinent issues of each segment will be examined so that techniques for identifying and priortizing potential MANTECH projects and implementation opportunities are established.

The Task Force effort will culminate in an investment strategy and implementation plan that will maximize the positive MANTECH impact on capabilities of AFSC contactors' industrial base.

APPROACH

Organization: The Task force is organized under the Director into three field teams and a Headquarters AFSC Management Team as shown in Figure 2.

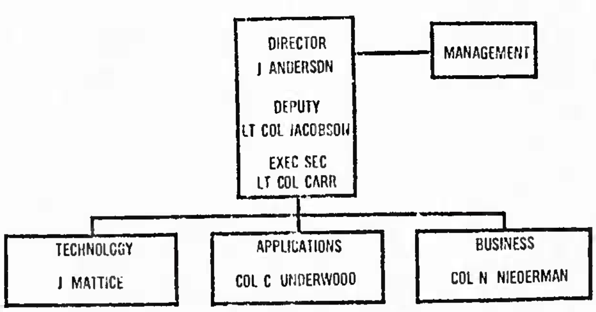

Figure 2. Task Force Organization

Responsibilities: Each team has been assigned specific charter objectives and associated tasks. The tasks are not all inclusive but are subject to modification, deletion and addition by the teams as they refine their individual plans.

The Technology Team will establish methodology for (1) examining the research and develoment base of Government and industry to identify technical opportunities, gaps and solutions related to manufacturing technology, and (2) obtaining the required funds through the Air Force budgeting process to conduct the MANTECH program.

The Applications Team will establish methods for (1) identifying the requirements for manufacturing cost reduction and productivity improvements, and (2) implementing successful MANTECH program results.

The Business Team will establish contractual methods for (1) promoting the application of advanced MANTECH improvements and capital investments, (2) recommending methods for tracking MANTECH benefits, and (3) establishing methods to improve the transfer of manufacturing technology information throughout industry and Government.

The Management Team (1) tracks Task Force progress toward achieving all charter objectives, (2) consolidates the Technology, Business, and Applications Teams recommendations into an overall investment strategy, (3) publishes policy and guidance for implementation of the strategy, and (4) establishes senior level management review of and feedback on the MANTECH program.

The conclusions and recommendations of each team will be consolidated into an overall strategy and implementation plan and submitted to Headquarters AFSC Management for approval.

Manufacturing and production issues must be considered early in the acquisition process, particularly in the conceptual, validation, and full-scale engineering development (FSED) phases. The opportunities for greatest impact and payoff of manufacturing technology and modernization efforts are at the beginning of the acquisition process. For example, consideration of advanced manufacturing technology requirements driven by conceptual designs and establishing manufacturing technology projects in the validation phase would make these "enabling" technologies available when needed in the production phase. Focusing on the productivity enhancement and modernization programs in the FSED phase and beyond will provide the "factory" analysis required to identify the cost and schedule drivers from an overall manufacturing point of view. Specific modernization programs can then be tailored for the system, contractor, or Air Logistics Center, such as was done for the F-16 Technology Modernization Programs. Essentially, the impact of applying

advanced manufacturing technology and structuring modernization programs occurs throughout the acquisition process. In fact, cost savings and other benefits can be realized even after the production phase has begun, but the impact is not as significant.

PROGRESS

The Task Force has caused manufacturing technology and technology modernization considerations to be included in the Draft Request for Proposals and statements-of-work for several acquisitions. Contractual language has been developed to implement modernization programs and track MANTECH Program benefits. Advanced manufacturing technology and modernization programs are now being considered in the source selection process so that the maximum leverage of competition can be brought to bear.

Several candidate system acquisitions, such as the CX Transport Aircraft, KC-135 reengine, B-52 Modernization, Advanced Medium Range Air to Air Missile (AMRAAM), Joint Tactical Information Distribution System, MX Missile, and NAVSTAR Global Positioning Satellite have been identified for technology modernization programs similar to the F-16 example. In addition, a direct interface with the Air Logistic Centers repair and maintenance operations has been established so that similar modernization programs can be arranged for Air Force facilities.

The Task Force is approximately midway through the data collection and analysis portion of the effort and expects to complete work by the end of May, 1980.

PRODUCTION DECISION FRAMEWORK: A DYNAMIC PLANNING MODEL

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ABSTRACT

This paper presents an understandable and straightforward method for making work force level and inventory planning decisions, i.e., aggregate planning.

The development phase defines a ratio, named RPCC. This ratio, representing the relative value of the cost of changing the production level to the cost of carrying inventory, is used to determine the length of an effective planning horizon. Two indicators are calculated to reflect the demand/capacity balance over different time periods. Based on the joint values of these indicators, the planning problem is subdivided into one of nine mutually exclusive and exhaustive states. A set of action statements, representing logical responses to each of the subproblems, is formulated.

After completion of the development phase, PDF's performance is tested in reality. Suggestions are made for further improvement.

INTRODUCTION

Aggregate planning is concerned with developing a specific course of action for the production system over an extended time period. As a result of unstable economic conditions currently existing, this activity has assumed added importance. Managers have become keenly aware of the substantial economic impact of work force and inventory level decisions on their firms' performance. Their objective in aggregate planning is to effectively allocate the available resources of capital and labor to meet the anticipated demand over the planning horizon. A partial list of available options is (1) varying the size of the work force, (2) varying the hours of a fixed workforce, (3) using seasonal inventory to absorb demand fluctuations, and (4) producing at a base level, allowing subcontractors to struggle with the problem of producing the excesses required.

Models proposed to solve the aggregate planning problem have historically been classified into three general categories: (1) those that yield optimal solutions, (2) those that are quasi-analytical and (3) those that are heuristic. While models in all three categories have been reported in the literature [1][2], their use in the industrial environment has been insignificant. Little [5] stated, "There have been a few applications, of course, but the practice is a pallid picture of the promise." Although many reasons have been given for the scarcity of their use, one possible answer lies in the perceived complexity of the mathematical or computer approach. Managers may not understand complex models and hence tend to reject that which they do not understand. Furthermore, faced with a myriad of production decisions, the manager may lack the time and background to understand a complicated model. The manager bears the responsibility for his decisions. Therefore, he must have confidence in any model he uses. The model should be dynamic and understandable: "dynamic" in that the model must be responsive to changing conditions; and "understandable" in that the user and others in management should be able to grasp the salient features of the model.

It is evident there is a serious gap between the approaches in academic journals and those in practice for meeting demand variations. Indications are that the typical manager does not take too seriously the search for optimality, seeking instead to find satisfactory decision rules that provide satisfying short-term solutions. Production Decision Framework (PDF) is a straightforward algorithm developed for such a manager. The model is based on Shearon's Manpower Decision Framework (MDF) [6], the major precursor of this work. Shearon proposed that two indicators for each planning period be calculated to reflect the demand/capacity balance over different periods of time--the short-term indicator and the long-term indicator. The short-term indicator is the ratio between the amount of production needed and the production level existing in the current period. Before deciding on a course of action, however, one must examine the ratio between the amount of production needed and the amount of production to be produced over the length of the planning horizon. This latter ratio is the long-term indicator. The short-term indicator, the Current Period Ratio (CPR), exists in one of three states: less than one, approximately equal to one, and greater than one. The long-term indicator, Planning Period Ratio (PPR), can be categorized in one of these three states also. Thus, it is possible to set up a 3x3 matrix to describe the possible combinations of these indicators. The matrix subdivides the planning problem into one of nine mutually exclusive and exhaustive states, as shown in Table 1.

Table 1

Manpower Decision Matrix

		CPR Indicator		
		CPR<1	CPR≈1	CPR>1
PPR Indicator	PPR<1	State 1	State 2	State 3
	PPR≈1	State 4	State 5	State 6
	PPR>1	State 7	State 8	State 9

A set of predetermined action statements, one for each of the matrix states, determines the reasonable current-period response in view of the current and longer-term production needs. An example of a set of reasonable responses is shown in Table 2.

Table 2

Sample Set of Action Statements

State 1:	Lay off employees to reduce production to the current level multiplied by the greater of the two indicators.
State 2:	Produce normally, but do not replace lost employees.
State 3:	Meet excess demand through overtime.
State 4:	Build inventory.
State 5:	Continue at the current level.
State 6:	Meet excess demand through overtime.
State 7:	Continue at current level, building inventory for the future demand.
State 8:	Hire new employees in anticipation of a production increase.
State 9:	Hire new employees. Use limited overtime to meet the current demand

Understanding the sequential nature of this planning process is important. A decision concerning the production rate for the current period cannot be termed good or bad by itself; its efficacy can only be appraised when viewed as part of a sequence of such decision over a period of time.

PDF MODEL

PDF is a dynamic model proposed to assist the manager in the planning process. The development phase of the model required (1) devising a method for selection of an effective planning horizon, (2) defining the CPR and PPR indicators, (3) specifying the "in balance" range limits for the two indicators, (4) defining a new indicator, the NPR, and (5) development of a set of action statements for responding to demand/capacity balances. The validation process consisted of testing the model vis-a-vis the Linear Decision Rule (LDR) model in the well-documented paint factory study [3]. Finally, a dimension of realism was added by measuring the performance of PDF against the current practices of two industrial firms. The selected firms were:

(1) American Furniture Company of Martinsville, Virginia
(2) Thiokol/Fibers Division of Waynesboro, Va.

Development

Planning Horizon (N)

The length of the planning horizon (N) is important to the success of the PDF model. The relationship between the cost of changing the production level and the cost of carrying inventory is the determinant in the selection process. The cost of changing the production level is defined as the sum of the costs of increasing and decreasing the production level by one unit per day by changing the size of the workforce. The inventory carrying cost is defined as the cost of carrying one unit in inventory for a period of one month. The ratio between these two variables will be referred to as the Ratio of Production to Carrying Cost (RPCC). Stated mathematically:

$$RPCC \equiv \frac{\left[(M \cdot \frac{E}{100})/(R \cdot 8)\right] \quad [H+L]}{(M \cdot \frac{C}{100})/12}$$

which can be simplified to

$$RPCC = \frac{1.5E(H+L)}{R \cdot C}$$

where M= manufactured cost/unit

E= direct labor in %

R= average hourly rate of direct labor employees

H= hiring cost/employee

L= layoff cost/employee

C= inventory carrying cost in % per year

A very low RPCC value dictates a chase strategy, i.e., changing the employment level to meet changing demand. The CPR dominates and a short planning horizon is effective in minimizing costs. Conversely, a very high RPCC value dictates a level production plan utilizing seasonal inventory to smooth the irregularities of the demand pattern.

It follows that lengthening the planning horizon will lower the cost of planning decisions, assuming reasonable accuracy of the expanded forecast.

A series of experiments was conducted to determine an appropriate value of N for a given RPCC value. These experiments were conducted ranging the RPCC values from 50 to 1000. This represents various combinations of inventory carrying percentages (15%-36%) and change in employment costs ($200-$2,000). Data from a company manufacturing a single product was the test vehicle. This company was selected for the study because of the challenging nature of the demand pattern, reflecting both high variability and strong seasonality. A linear program was used to allocate the firm's resources. The objective was to minimize the incremental costs associated with planning decisions over a fixed time horizon. For each RPCC value tested, two sets of annual planning decisions were determined. The first, a static plan, was an LP solution based on a time horizon of twenty four months. The second, a dynamic plan, was a "rolling" LP solution, using the shortest time horizon consistent with near minimal planning cost. "Near minimal cost" was defined as being within approximately five percent of the optimal static plan. The scenario for development of the dynamic plan is shown in the following table. Consideration of a planning horizon focused on a period of three months or longer, a logical starting point.

Table 3

Determination of Dynamic Plan

Step 1.	Select the RPCC test value.
Step 2.	Set N=3
Step 3.	Solve the model, determining the imminent decision only.
Step 4.	Update the model to reflect the impact of that decision.
Step 5.	Return to Step 3 until twelve consecutive decisions have been established.
Step 6.	Calculate the incremental costs associated with the developed plan.
Step 7.	Compare the dynamic plan cost with optimal. If near-minimal results were obtained, accept the plan and the planning horizon. If not, increase the planning horizon by one and return to Step 3.

It was possible to simulate the actual environment by using a "rolling" LP consisting of a sequence of decisions determined by successive solutions of a finite, multi-period model. The determination of the relationship between the length of the planning horizon and the efficiency of the rolling schedule, over the range of RPCC values, could then be made. The results are shown in Table 8.

CPR Indicator

The amount of product needed for the current period includes the demand for the current period and the backorders carried over from the previous period. Clearly, the decision process cannot ignore excess inventory. This accumulation is planned for absorbing part of the peak demand requirements over a period of several months. Thus, if the current demand exceeds the current production level, up to one-third of the seasonal inventory is used to balance the two, i.e., reduce the CPR to 1. Depleting the inventory reserves more rapidly not only defeats the purpose of the buildup, but it also can produce a harmful oscillatory effect on the CPR indicator. The CPR is defined as follows:

$$CPR_i \equiv \begin{cases} \left(\dfrac{D_i + B_{i-1}}{A_i}\right) \cdot P_{i-1}^{-1} & \text{if} \le 1 \\ \text{MAX } 1, \left(\dfrac{D_i + B_{i-1} - 1/3\ I_{i-1}}{A_i}\right) \cdot P_{i-1}^{-1} & \text{otherwise} \end{cases}$$

where CPR_i = Current Period Ratio in period i.

D_i = Demand in period i.

B_{i-1} = Backorders at end of period i-1.

A_i = Number of production days in period i.

P_{i-1} = Production/day in period i-1.

PPR Indicator

The amount of product needed over the length of the planning horizon includes the demand for each period in the planning horizon and the backorders carried over from the previous period. However, as in the CPR indicator, the excess inventory must be taken into consideration.

When the RPCC value dictates a chase strategy and a short planning horizon, all of the excess inventory should be used in meeting the total demand. Conversely, for level production, the production rate should be based on the average demand for the season, ignoring inventory buildup. It follows that the length of the planning horizon should determine the percentage of inventory to be used in the PPR equation. This schedule, determined empirically, is used for the inventory adjustment:

Planning Horizon	Inventory Adjustment (F1)
1 to 5	100% of inventory
6	80% of inventory
7	60% of inventory
8	40% of inventory
9	20% of inventory
10+	0% of inventory

The PPR indicator is defined as follows:

$$PPR_i \equiv \left\{ \frac{\left(\sum_{j=i}^{i+N-1} D_j\right) + B_{i-1} - Fl \cdot I_{i-1}}{\sum_{k=i}^{i+N-1} A_k} \right\} \cdot P_{i-1}^{-1}$$

where PPR_i = Planning Period Ratio in period i

Fl = Inventory adjustment factor.

N = Planning horizon length.

The CPR and PPR indicators are the sole determinants of the matrix state. Once the state is defined, management should react logically to any disequilibrium that might exist. In several of the matrix states, additional information is valuable in determining the appropriate action to be taken. Thus a third indicator, the Net Period Indicator (NPR), was defined to provide that information.

CPR and PPR Limits

The CPR was arbitrarily assumed to be balanced in the range of $1 \pm .05$. The lower limit of the balance state of the PPR indicator also was set at 0.95. The upper limit was lowered to 1.025 to make the longer-range indicator a more sensitive barometer of increases in expected demand. The PDF state can be selected from Table 4.

assigned to current demand, available to meet the current excess demand. There is no logical reason for saving this excess inventory for the future when the current production rate already exceeds the average demand over the planning horizon. A similar situation can exist in states 1, 6, and 9 - those states where the CPR is unbalanced (not equal to one) and yet can be higher than the PPR.

A new indicator, NPR, was defined to aid in the decision process. NPR differs from CPR only in that all of the excess inventory is subtracted from the demand in computing the ratio. Thus, it is possible to determine if there is sufficient inventory to meet the demand surge for the current month. The formula is:

$$NPR_i \equiv \left(\frac{D_i + B_{i-1} - I_{i-1}}{A_i}\right) \cdot P_{i-1}^{-1}$$

Action Statements

The current period response for a given matrix state is expressed as a production adjustment factor (PAF). This factor is defined as the proportion by which the production rate should be adjusted to meet anticipated demand. The strategy for making the adjustments is left to the preference of the user for each matrix state. The formula is as follows:

$$P_i = P_{i-1} \cdot PAF$$

Table 4

PDF State Indicator

	CPR < .95	.95 ≤ CPR ≤ 1.05	CPR > 1.05
PPR < .95	1	2	3
.95 ≤ PPR ≤ 1.025	4	5	6
PPR > 1.025	7	8	9

NPR Indicator

Consider state 3 with a high CPR (greater than one) and a low PPR. The condition normally occurs at the peak of the demand in a highly seasonal industry. The CPR value signifies that demand exceeds capacity for the current period. Over the long term a reduction in output is suggested. Without additional information, the manager has the option of increasing production for the current month (hiring or overtime) or maintaining the current level, expecting to accumulate backorders. Perhaps there is enough seasonal inventory, un-

The series of "rolling" LP solutions obtained in the planning horizon experiments were used to study the relationship between the matrix state, as determined by the CPR and PPR, and the optimum response of the LP solution. Thus, an empirical and logical set of production adjustment factors evolved which are used as response decisions. The production adjustment factors are shown in Table 5. In five of the nine matrix states, the production adjustment factor is a value equal to the CPR, NPR, PPR, or 1. In the remaining four states, the adjustment factor is a compromise between the

CPR and PPR as shown below:

$$PAF = CPR + X\ (PPR-CPR)$$

where $0 \leq X \leq 1$.

Determining X Values

Resolution of the optimium X value question completes the planning model. For each value of RPCC used in the experiments, the X value was ranged from 0 to 1 in steps of 0.1. The resulting costs are shown in Table 6 and the optimum X value (lowest cost) for each run has been circled.

Several important observations can be made concerning these results. First, in each experiment the costs consistently declined as the X value was increased until a "bottoming out" occurred. In all but five of the runs, the costs "bottomed out" at an intermediate X value. In the remaining five, the lowest cost was encountered when the X value was equal to one. Second, for a given planning horizon, the optimium X either increased or remained unchanged in subsequent runs with higher RPCC values. Once the X value reached one, further leveling of production for the higher RPCC values required lengthening of the planning horizon. This was consistent with the expectation that the value would "fine tune" the model within a given horizon. The major adjustment in the "level vs chase" strategy is accomplished by changing the planning horizon.

Table 5

Production Adjustment Factors

State	PAF	RPCC
1	Max [NPR, CPR + X (PPR - CPR)]	≤350
	Max [CPR, PPR]	>350
2	1 (No change)	All
3	Max [1,NPR]	≤350
	1 (No change)	>350
4	1 (No change)	All
5	1 (No change)	All
6	Max [1,NPR]	≤350
	1 (No change)	>350
7	Max [1, CPR + X (PPR - CPR)]	≤350
	1 + X (PPR -1)	>350
8	Max [1, CPR + X (PPR - CPR])	≤350
	1 + X (PPR - 1)	>350
9	Max [NPR, CPR + X (PPR - CPR)]	≤350
	CPR + X (PPR - CPR)	>350

PDF Applied

The sequence to be followed in applying PDF to an aggregate planning problem is:

(1) Calculate the RPCC value.

(2) Select the appropriate planning horizon (N) and X value from Table 7.

(3) Finalize the production adjustment factors in Table 5 by substituting the selected value of X.

(4) Compute CPR, NPR, and PPR.

(5) Determine the matrix state from Table 4.

(6) Make the appropriate production adjustment for the current period.

Table 6

PDF Costs for Ranging X Values ($)

Run	RPCC	Plan Horizon N	X Values 0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
1	50	3	7,569	7,008	6,850	6,819	6,789	6,871	6,978	7,168	7,357	7,927	7,871
2	100	3	12,397	11,824	11,586	11,453	11,319	11,196	11,074	11,000	10,928	11,350	11,027
3	150	3	16,974	16,421	16,121	16,121	15,700	15,394	15,069	14,757	14,448	14,695	14,183
4	200	3	21,682	21,130	20,762	20,459	20,159	19,659	19,117	18,553	17,994	18,085	17,339
5	250	3	26,392	25,840	25,403	25,009	24,619	23,924	23,166	22,350	21,541	21,476	20.495
6	300	4	31,256	31,484	30,982	30,463	29,826	28,540	27,062	25,389	24,653	24,246	23,534
7	350	4	36,073	36,339	35,733	35,107	34,332	32,746	30,911	28,824	27,863	27,267	26,310
8	400	5	34,277	33,700	33,729	32,833	32,055	31,530	29,074	28,263	27,849	28,270	28,009
9	450	7	37,373	36,794	36,662	37,921	33,563	30,827	30,613	34,347	36,421	37,815	38,791
10	500	8	64,508	38,623	37,184	38,464	33,363	31,146	35,149	37,843	38,241	39,962	41,394
11	550	9	65,413	41,938	37,337	42,514	34,349	31,214	33,015	36,896	38,407	39,214	40,724
12	600	10	66,318	69,614	39,324	49,610	37,923	33,087	30,583	33,478	34,234	34,949	35,733
13	650	10	67,223	70,415	41,271	50,362	38,833	34,038	31,509	34,745	35,523	36,226	37,034

Table 7

Planning Horizon - X Value Selector

RPCC Value	Planning Horizon (N)	X Value
0 to 50	3	0.4
51 to 100	3	0.8
101 to 250	3	1.0
251 to 350	4	1.0
351 to 400	5	0.8
401 to 450	7	0.6
451 to 500	8	0.5
501 to 550	9	0.5
551 to 650	10	0.6
Above 650	12	1.0

A comparison of the plans and costs of the three plans -- static L.P., dynamic L.P., and PDF -- are given in Table 8. It is worth noting that the mean cost of PDF was 2.4 percent above the dynamic and 5.7 percent above the static plans. In only the first run did PDF costs exceed the dynamic plan by as much as 5 percent. Similarly, PDF exceeded the static plan by as much as 10 percent only once.

Validation. Since the PDF methodology was developed using linear cost relationships, successful application in a non-linear situation would further test the validity of the approach. It was hypothesized that a set of reasonable responses to each of the planning subproblems would produce satisfying results in both linear and non-linear environments.

The Linear Decision Rule (LDR), developed by Holt, Modigliani, Muth, and Simon (HMMS) [3] and tested in a paint factory, offered a well-documented study to serve as a basis for comparison. First it was necessary to use a linear approximation of two of LDR's quadratic cost functions for determination of an RPCC value. These approximations are shown in Figure 1.

Based on these linear approximations, an RPCC value of 238 was calculated. All the incremental costs associated with the planning decisions were computed with the assumption that LDR cost functions represented the real world situation.

Table 8

Cost Comparison of Various Plans

Run No.	RPCC Value	Static L.P.		Dynamic L.P.		PDF			% PDF over Dynamic	% PDF over Static
		P.H.*	Cost	P.H.*	Cost	P.H.*	X	Cost		
1	50	24	$ 6,067	3	$ 6,189	3	.4	$ 6,789	9.7	11.9
2	100	24	10,166	3	10,570	3	.8	10,928	3.4	7.5
3	150	24	13,688	3	13,945	3	1	14,183	1.7	3.6
4	200	24	16,287	3	17,016	3	1	17,339	1.9	6.5
5	250	24	19,096	3	20,087	3	1	20,495	2.0	7.3
6	300	24	21,634	4	22,568	4	1	23,534	4.3	8.8
7	350	24	23,959	4	25,102	4	1	26,310	4.8	9.8
8	400	24	26,054	5	27,557	5	.8	27,849	1.1	6.9
9	450	24	28,169	7	29,762	7	.6	30,613	2.9	8.7
10	500	24	30,195	8	31,858	8	.5	31,146	0	3.1
11	550	24	32,026	9	31,749	9	.5	31,214	0	0
12	600	24	30,666	10	33,168	10	.6	30,583	0	0
13	650	24	32,182	10	33,395	10	.6	31,509	0	0
								Mean %	2.4	5.7

*Planning Horizon

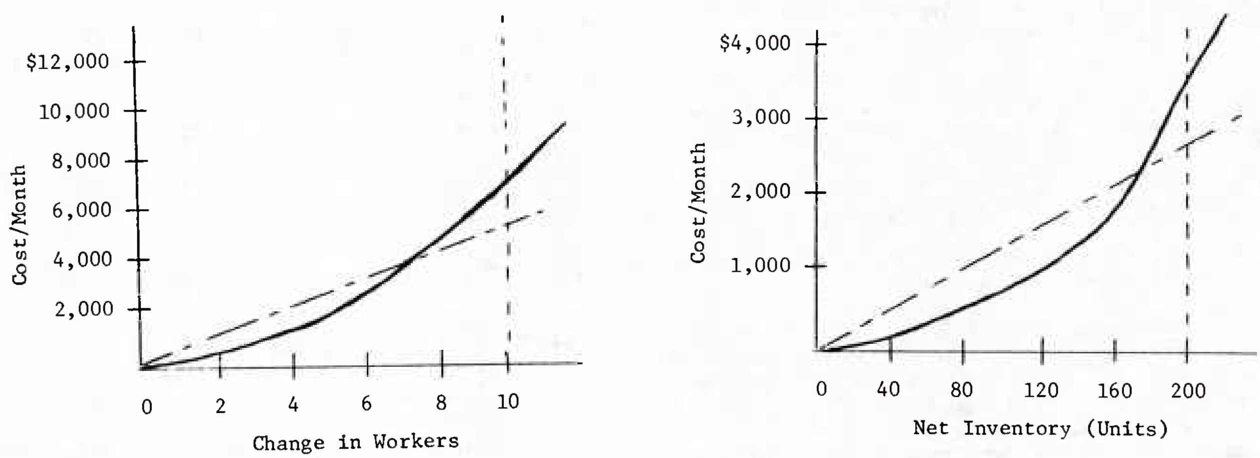

Figure 1
Approximating Linear and Quadratic Cost Functions

The total cost of PDF was $743,030 (or 1.2 percent above LDR). A cost comparison between the two methods is shown in Table 9.

One concern was the possible effect on the cost in the LDR comparison which might result from an error in the estimation of RPCC from the quadratic curves. The 3-month planning horizon and X value of 1 apply for an RPCC value bounded at 101 at the low

Table 9

Cost Comparisons for Paint Factory Study

Cost Element	LDR	PDF
Straight-time Labor	$670,395	$682,720
Overtime	46,097	27,764
Hiring and Layoff	11,804	25,077
Inventory	5,880	7,469
	$734,176	$743,030

end to 250 at the upper end. Therefore, an error in excess of 5 percent on the high side would change the planning horizon and X value to 4 and 1, respectively. An analysis was made of the planning decisions and associated costs using the longer horizon. As expected, more relevance was placed on the use of seasonal inventory to meet the demand peaks. The inventory cost increased from $7,469 to $20,325, while the hiring and layoff cost dropped. The total cost over the 2-year period was $751,453 (or only 2.4 percent above the optimium LDR costs).

PLANNING ACTIVITIES IN TWO FIRMS

Two firms were studied for an in-depth look at their costs and aggregate planning activities. The purposes were:

(1) To isolate the costs associated with each of the pure options available (i.e., varying the work force, changing the hours worked, and use of seasonal overtime). Backordering was allowed with a penalty cost of 6% per month of the value of such backorders.

(2) To develop a PDF plan for meeting this demand using the actual sales for the past fiscal year.

(3) To reconstruct the actual decisions made by each company during the study period.

(4) To test the efficacy of PDF as measured by the current planning decisions.

American Furniture Company. The demand pattern for the year 1978 was far different from any previously tested using PDF. The length of seasonality was three months with local peaks occurring in the second, fifth, eighth, and, eleventh months. The demand in each of the peak months averaged 31 percent above the demand of the preceding month. Furthermore, the plateaus were of short duration, lasting only one month before descending to the previous levels. Coupled with the short seasonality length was the apparent upward trend over the course of the year.

The following four plans were developed:

(1) The reconstructed "Actual Plan" for 1978.

(2) A "Level Plan" with a constant production rate throughout the year.

(3) An "Intermediate Plan" with four production changes over the period, i.e, change for each of the four seasons.

(4) The "PDF Plan" with a 5-month planning horizon and X value of 0.8 (RPCC = 354).

The cost summaries of the four plans are shown in Table 10. The Actual Plan costs were over 100 percent higher than any of the other three plans. This resulted from the high overtime premium costs and, to a lesser extent, the seasonal inventory carrying costs. The totals of the Intermediate and PDF plans were almost identical. In the last month of the year, PDF made the production adjustment to meet the demand anticipated for the first three months of 1979, whereas the Intermediate Plan did not. Therefore PDF's cost was the lowest, considering the rate adjustment necessary to bring the Intermediate Plan's production in line with future demand.

Thiokol/Fibers Divisions. Management was faced with a typical dilemma - how to minimize changes in the employment level, while limiting the buildup in finished goods inventory. The problem of resolving these conflicting goals was magnified by the fluctuating, hard-to-predict demand. Thiokol's management followed a conservative plan of moderate production level changes, controlling the finished goods inventory within specified limits. This policy was considered by Thiokol's management to be a good compromise between level production, with high seasonal inventories, and production to order, with minimum inventory buildup.

The following six plans were compared. The last two plans were developed in light of Thiokol's propensity to level production.

(1) The reconstructed "Actual Plan."

(2) A "Theoretical Plan" developed by applying management's stated decision rules for meeting changing demand.

(3) A "Level Plan" with a constant production rate.

(4) A "Standard Plan" using PDF with a planning horizon of 3 months and X value of 1 (RPCC = 199).

(5) An "Alternate 1" PDF plan based on the next higher planning horizon of 4 months (RPCC from 251 to 350).

(6) An "Alternate 2" PDF plan based on a planning horizon of 5 months and X value of 0.8.

PDF proved efficient in adjusting the production to meet demand. The cost using this methodology

Table 10

American Furniture Company

Cost Summary of the Four Plans
($M)

Cost	Actual	Level	Intermediate	PDF
Seasonal Inventory	186.1	247.9	115.1	91.9
Overtime	382.4	0	0	0
Production Changes	169.8	129.6	192.5	187.9
Negative Inventory	31.4	0	0	27.9
Total	769.7	377.5	307.6	307.7

Table 11

Cost Summary of All Plans ($M)

Cost	Actual	Level	Theoretical	Standard	Alternate 1	Alternate 2
Seasonal Inventory	269.4	315.1	257.3	60.0	111.8	146.6
Overtime	39.8	0	0	0	0	3.4
Production Changes	46.5	23.3	57.7	127.8	76.9	55.7
Negative Inventory	0	0	0	5.5	5.8	0
Total	355.7	338.4	315.0	193.3	194.5	205.7

was 39% percent less than the plan based on management's decision rules, as shown in Table 11. The Standard PDF plan resulted in the lowest total cost. Alternate 1 and Alternate 2, with 4 and 5 month horizons, respectively, have slightly higher costs as shown in Table 11. There is a strong possibility that management would have preferred one of these two, considering the qualitative aspects to outweigh the slight cost disadvantage.

SUMMARY

This research effort was directed toward the development of a dynamic method for solving the aggregate planning model. Emphasis was placed on developing a logical, understandable, and straightforward model. Future research should focus on the following:

(1) Testing alternate forms of the NPR equation. Preliminary tests indicate that the inclusion of additional months in the indicator equation improve the model's performance.

(2) Studying the impact of low productivity of new employees on the planning decisions.

(3) Performing a sensitivity analysis on the PDF state selector to determine optimium range values.

(4) Studying the impact of forecasting uncertainty on the efficacy of PDF.

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CONCEPT AND ASSESSMENT OF THE VALIDATED DRAWING PROGRAM IN THE FFG-7 CLASS SHIP ACQUISITION

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ABSTRACT

Ship acquisition programs which contain "lead" and "follow" ships require a system through which the follow shipbuilder(s) has access to reliable working drawings. To provide for this in the FFG-7 Class ship acquisition program, the Navy has instituted a unique system for validating the lead ship working drawings. The objective of this system is to provide drawings which the follow shipbuilders can use and in doing so to: minimize the cost of duplicative design effort; promote standardization of the ships of the class; ensure that solutions to design problems found in constructing the lead ship are utilized in the building of the follow ships; and provide for necessary changes to the working drawings without the delays inherent in the configuration control system. The study reported herein documents the validated drawing concept and its worth and applicability to future ship acquisitions. In general, the program is meeting its objectives. There are important lessons learned, however, which should be considered when applying the validated drawing concept to other ship acquisition programs.

BACKGROUND

Ship acquisition programs which contain "lead" and "follow" ships require a system by which the follow shipbuilder(s) has access to reliable working drawings which can be used to construct the follow ships and which accurately depict the ship the Navy desires. If each individual follow shipbuilder is responsible for developing the working drawings he requires, duplicative design costs will be incurred. In addition, there will be a lack of standardization between the ships from different builders as each solves the problems of detail design in isolation from the other. On occasion in the past, the Navy has attempted to minimize the duplicative design costs and retain the maximum standardization by providing lead ship working drawings to follow shipbuilders for their use "if desired." In doing so, however, the Navy disclaimed responsibility for the accuracy or suitableness of the drawings because it had not in fact confirmed these qualities. In practice, the Navy disclaimers have been held invalid in contractual disputes. The Navy must either pay for duplicative design (and accept any resulting nonstandardization) or be responsible for the drawings it provides follow shipbuilders. The FFG-7 Class program, with a lead and three follow shipbuilders, addressed the dilemma described above through utilization of a "lead-follow" design and construction concept which includes a program for providing working drawings to follow shipbuilders with a warranty of their validity.

The objective of this program is to provide for reliable working drawings which the follow shipbuilders can use to construct the follow ships and, in doing so, to:

a. minimize the cost of duplicative design effort.

b. promote standardization of the ships of the class.

c. ensure that solutions to design problems found in constucting the lead ship are utilized in the building of the follow ships.

d. provide for making necessary changes to the production drawings without the delays inherent in the configuration change control system.

PROGRAM CONCEPT

The concept of the FFG-7 Class Validated Drawing Program is to provide to follow shipbuilders working drawings and other documentation of such quality and accuracy to enable the Navy to warrant that ships built in accordance with those drawings and documentation will meet the contract specifications. This is done in the following manner:

a. The lead shipbuilder validates through an intensive design quality assurance (QA) procedure, feedback from the waterfront mechanics and a physical verification process that the drawings and material lists used to construct the lead ship of the class accurately depict the ship as built and that test procedures used to test the lead ship confirm that the ship meets the specifications.

b. The government furnishes the validated drawings and material lists to follow shipbuilders with a warranty that ships built in conformance with such documents will meet the contract specifications.

c. The follow shipbuilders have the option of using the validated documents or departing from them. The option to depart is provided primarily because:

(1) shipyards do not have the facilities or utilize standard practices which enable each of them to construct ships in exactly the same way.

(2) the use of alternate sources of Contractor Furnished Equipment (CFE) or Government Furnished Equipment (GFE) may require different working drawings for installation.

If follow shipbuilders elect to depart from validated drawings for these or any other reasons, they assume the responsibility for meeting the specifications.

d. If it becomes necessary for the Navy to change a validated drawing, either to correct an error or to institute a change, the government agrees to make an equitable adjustment of the contract for any cost or schedule impact on the shipbuilder.

The program, therefore, consists of two processes: (1) an integrated design/construction/inspection process for physical validation of the construction drawings, and (2) an administrative process for scheduling and issuing validated drawings, for revising the drawings when desired and for equitable adjustment of contract due to the impact on the follow shipbuilders of the revisions.

VALIDATION PROCESS DESCRIPTION

The validation process is shown graphically in Figure 1 and is described briefly below.

a. Detail Design Phase. During the detail design phase, the Lead Shipyard's Design Agent (LDA) develops necessary working drawings to meet specification requirements. The drawings are subjected to intensive internal design quality assurance checks to ensure accuracy and completeness.

b. Lead Ship Construction Phase. The working drawings produced by the LDA are used to construct the lead ship. Shipbuilder trade mechanics are instructed to notify the waterfront design liaison group of any drawing discrepancy or changes required/desired to satisfactorily accomplish the work. This information is fed back to the lead shipbuilder and the LDA for consideration, resolution of discrepancies and revisions to drawings as required.

In addition to the rigorous feedback, selected drawings are subjected to verification by ship or land based test site checks. Based on the actual physical inspection, either compliance with the specifications and drawings as shown is confirmed or necessary changes identified.

The lead shipbuilder validates drawings to the Navy (lead Supervisor of Shipbuilder) in accordance with a contractual schedule. The Supervisor of Shipbuilding (SUPSHIP) reviews the drawings to ensure that all known corrections have been made. The SUPSHIP also verifies selected drawings by shipcheck. In the FFG-7 program, approximately one-third of the drawings were independently shipchecked by the SUPSHIP. This shipcheck by SUPSHIP is in addition to the shipcheck performed by the lead shipbuilder.

c. Follow Ship Construction Phase. The follow shipyards receive validated drawings in accordance with a schedule, included as an attachment to the contract schedule, which supports their construction schedules. The follow shipbuilder either elects to use the validated drawings or not to use them. If he uses the validated drawings, the government warrants that, if followed, the drawings will produce a ship that satisfies the specifications. If for any reason the follow shipbuilder elects not to use a validated drawing, he then assumes the responsibility for meeting specification requirements. In this case, the shipbuilder is required to notify the Navy of his intention and, at the Navy's request, to establish the feasibility of compliance with the ship specifications before departing from the validated drawing.

In the course of construction, the follow shipbuilder may discover errors in the drawings. Such errors are reported by a drawing change notice (DCN) to the local SUPSHIP. The local SUPSHIP may either provide resolution directly or refer the DCN to the lead SUPSHIP. In either instance, final resolutions are incorporated into the construction drawings as appropriate.

In summary, the validated drawing process involves intensive quality assurance during detail design; rigorous feedback to design of construction experience on the lead ship from the waterfront; verification by actual inspection of the lead ship; and a continuing system for feedback of contruction experience from follow shipbuilders.

PROGRAM WORTH

In considering the worth of the Validated Drawing Program, it is necessary to recognize that it is a part of the total acquisition strategy. Its worth cannot be evaluated in isolation from the elements and objectives of the total strategy. Therefore, in assessing the program's worth,

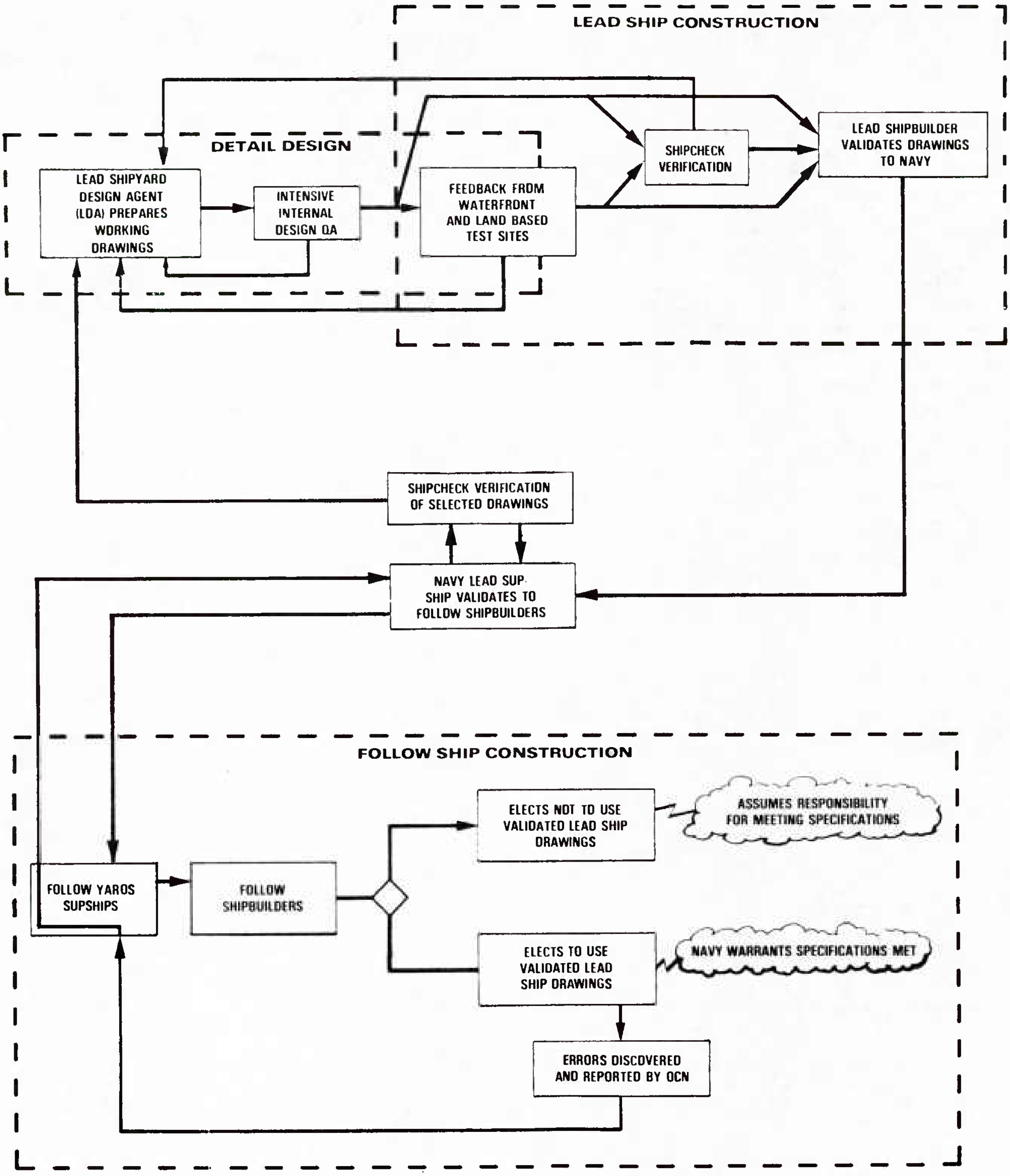

FIGURE 1. VALIDATION PROCESS

beneficial and adverse side effects are considered as well as the program's cost and the degree to which its specific objectives are being met.

Accomplishment of Objective. The basic objective of the FFG-7 Class Validated Drawing Program is to make available to follow shipbuilders reliable working drawings which the follow shipbuilders can use to construct the follow ships. The three follow shipbuilders, all experienced in previous Navy multi-ship construction programs, are using the Navy validated construction documentation. Without exception, they report that the quality of the construction drawings is excellent. The first of the follow ships from each follow shipyard has been delivered. There have been no major technical or material problems and all were either on or ahead of schedule. It is concluded, therefore, that the Validated Drawing Program has met its objective.

Beneficial Side Effects. There are other benefits to the Government and to the shipbuilders associated with the validated drawing concept beyond that of the stated objective in the FFG-7 Class program. These side effects could be accomplished through other means and therefore are not credited solely to validated drawings per se. However, it is appropriate to call attention to them because of their inseparable relationship with the validation concept. Chief among these are:

a. The quality of drawings from the standpoint of clarity, accuracy and reproducibility has been excellent. Users of the drawings, who also had experience in the DE-1052 multi-builder program with the same LDA but without validated drawings, specifically have called attention to the improvement in drawing quality. In addition, the engineering appears to be reliable, as evidenced by the fact that all three follow shipbuilders are on or ahead of schedule, without major material or technical difficulties. The intensive QA on the part of the LDA certainly is a factor in these benefits.

b. A reliable basis for configuration control has been established. Previous acquisition strategies did not require that the construction documentation precisely portray the ship(s) as built. Since the Navy rarely has an accurate technical description of its ships as built, imprecise configuration control baselines have resulted. Because of the Validated Drawing Program, there is now an accurate configuration control baseline for the FFG-7 Class.

c. Lessons learned during construction are being thoroughly documented. In acquisitions where each shipbuilder prepares his own detailed design for the ship(s) he is building, trade mechanics in each yard may on occasion depart from drawings to overcome minor interference problems as they install systems in the ship. Rarely are the drawings revised to reflect any changes made. In these cases, the Navy pays the bill for multiple designs and the various yards and mechanics repeatedly solve the same problems. Under the validated drawings concept, drawings are revised to show the lead ship as built. This documenting of lessons learned is available to all builders and duplication of the learning process is minimized.

d. The special feedback from the waterfront to the design activity can produce a beneficial rapport between the waterfront and design. This rapport and the stringent requirements for feedback from the waterfront to design has fostered a "cross-fertilization" and exchange of technical knowledge that should benefit future designs.

e. The FFG-7 Class Validated Drawing Program has fostered a cooperative relationship between the government and the shipbuilders. This cooperation started with the early participation of all the follow shipbuilders in producibility reviews during the period of contract specification preparations. It extended into the lead ship construction and test period wherein open exchange of information between the Navy and the shipbuilders appears to have reduced the potential for contractual misunderstandings.

f. The validated drawing concept in effect provides a monetary incentive to follow shipbuilders for standardization. In the FFG-7 Class program this incentive appears to be a significant factor in follow shipbuilder decisions. The potential long range cost savings to the Navy in logistic support over the life cycle of the ships is substantial.

Adverse Side Effects. The following are adverse side effects to the validated drawing concept. Some of these cannot be attributed to the program itself but are included as potential problems in an acquisition strategy which includes the concept.

a. There have been a larger number of revisions to the validated drawings than anticipated. The contract provides for revising construction drawings and compensating the shipbuilders for any adverse impact the revisions have on the construction process. Procedures for accomplishing, documenting and accounting for the revisions have evolved and are considered adequate at this time. However, only 3 months after delivery of the lead ship, more than 11,000 revision notices and drawing revisions had been received by follow shipbuilders. This volume created a significant, unplanned administrative workload on the follow shipbuilders, the LDA and their respective SUPSHIPs. The administrative workload stems from the following.

(1) The accounting and control procedures necessary to ensure the continuous updating of the validated baseline.

(2) The analysis necessary to assess the impact of revisions on work in process, scheduled or completed.

(3) The adjudication process for determining appropriate equitable adjustment to the contract.

There are three principal causes for the large number of revisions to the validated drawings. First, the length of time between the lead ship construction schedule and the dates the working drawings were required to support the follow ship schedule was insufficient in many cases to allow for verification of all drawings by observation in the lead ship before their use on the follow ships. Second, there were a number of changes to validated drawings resulting from the analysis of certain tests performed after delivery, such as the full scale shock tests, and from feedback from the lead ship's crew during the shakedown period. Ideally, to eliminate these causes for revisions, drawings should not be validated until the lead ship is built and all testing completed and analyzed. This is impractical and undesirable in most multi-ship programs because of follow ship scheduling considerations. As a result, a compromise in the construction schedules of the lead and follow ships must be reached taking into account the risk of overburdening construction management with changes and the risk of unduly delaying follow ship construction.

A third cause for changes in construction drawings after their validation appears to be delays in initiation by the lead shipbuilder of design changes into the administrative system for updating drawings. There is evidence that in some cases, required revisions were probably identified by the lead shipbuilder and actually utilized in the construction of the lead ship before the drawings were validated. However, they were not processed in time to be included in the drawings as of their validation dates. In these cases, post validation revisions were necessary. This problem has not been analyzed by the author of this report. However, from his general knowledge of the program in operation, it is the opinion of the author that the problem is one of engineering personnel workload. In the outfitting, test and check out phase of lead ship construction, when the bulk of potential revisions to drawings are identified, the shipyard engineering personnel were heavily committed to predelivery activities. This intensive engineering support carries over for a number of months after delivery as Board of Inspection and Survey (INSURV) and shakedown discrepancies are identified. It is probable that as a result of these factors, the engineering personnel delayed in processing design change notices. The length of time between lead and follow ship construction undoubtedly was a factor in the situation. In addition, the lead shipbuilder probably had an internal system which gave him confidence that lessons learned on the lead ship were being utilized on his first follow ship. In any case, the problem is considered procedural and not fundamental to the concept of validated drawings.

Figure 2 illustrates graphically the experience on the FFG-7 program with drawings used on the first follow ships. The validated drawings were issued on the schedule which was determined at the time of issuing the first follow ship request for proposal (RFP) to be necessary to support the FFG-8 (first follow ship) construction. The revisions to those drawings were processed during a ten month period after that schedule was

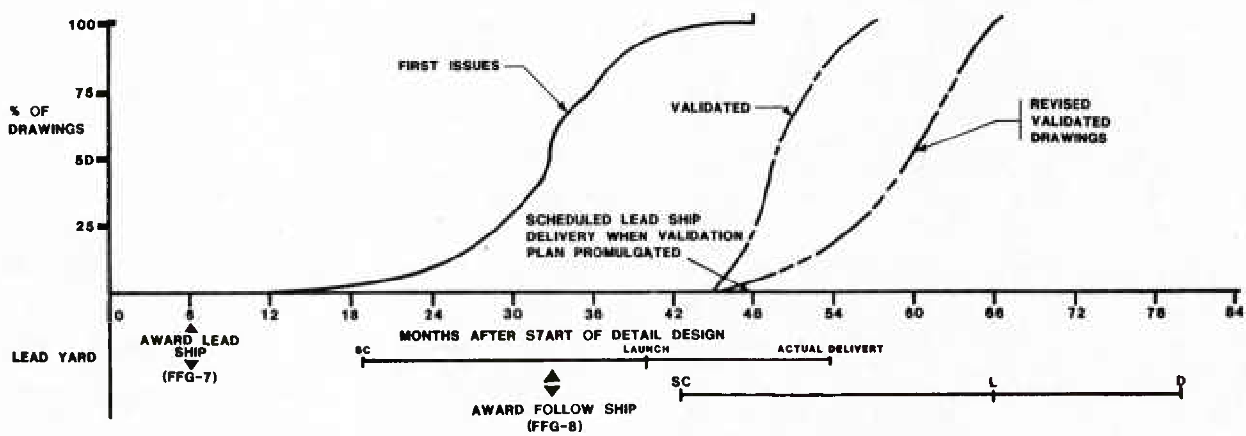

FIGURE 2. FFG-7 CLASS VALIDATED DRAWING ISSUES/VALIDATION/REVISION HISTORY

completed. At the time of issue of the follow ship RFP, the lead ship delivery was scheduled 30 months after start of construction. Subsequent to the issue of the follow ship RFP, the lead ship delivery was rescheduled to a six months later date. This undoubtedly was a factor in the total number of revisions which were processed.

The majority of the revisions to the validated drawings, for whatever cause, were minor and had little impact on the construction progress of the first flight of follow ships. The drawings had been subjected to the LDA's rigorous QA and the waterfront feedback to the designer during construction of the first ship. Many of the revisions were simply configuration documentation updates. Despite these facts, the large number of revisions creates an administrative workload and an impression of excessive design change. The result can be unfavorable publicity concerning government and shipbuilder management of changes. This is a typical problem in any program with rigorous configuration documentation and control but is mentioned here especially because validated drawings have application to high visibility programs; i.e., multi-ship, multi-builder.

b. The potential heavy administrative workload which is associated with large numbers of revisions to validated drawings introduces the possibility of diversion of shipbuilder and SUPSHIP resources from productive activity. This becomes a hidden cost of the program which is difficult to identify or budget for.

c. The necessity for standardization of equipments potentially is a significant procurement problem in a multi-ship/multi-year program. Equipment manufacturers who are successful in the lead ship competition become in effect the sole source for follow ship equipment. In such a situation, the vendor has an advantage which may tend to result in excessive price increase for follow ships. Additionally, there are vendors who decline to bid on follow ship equipment after supplying equipment for the lead ship. Even with continuing vendors, technology or manufacturing changes can result in changing configurations of equipments bought in different years. These factors impose problems in standardization which complicate a validated program.

d. The government warranty of drawing reliability in the validation concept transfers some risk from the follow shipbuilders to the government. This theoretically is reflected in lower bid proposals. The survey conducted in connection with this report confirms the validity of this theory although it was not quantified or documented. This situation creates a practical problem for the ship acquisition project manager (SHAPM), however, in justifying funds for the validation process and for changes and "equitable adjustments" which are part of the concept. The equitable adjustments are in effect settlements for government actions before they become the subject of claims. There are emotional as well as technical difficulties in justifying the need for such funds, but the matter should be addressed by those comtemplating using the program.

e. The possibility of real or contrived misunderstandings of contractual provisions for validated drawings will always exist. The intent of the government, as exhibited by its actions when those actions are interpreted as inconsistent with the contract, has been questioned by individuals interviewed during the course of this study. For example, the relative precedence of validated drawings and the contract specifications could be questioned. If the government is not as prompt in updating specifications as it is in updating validated drawings, follow builders could take the position that the validated drawings supercede the specifications. This point is included under "adverse effects" for the sole purpose of emphasizing that any complex contractual provision is subject to different interpretations which are the groundwork for disputes and claims. The Validated Drawing Program is no exception.

f. There is no provision for the routine feedback of information developed during the validation process to the Naval Sea Systems Command technical codes. This is not a major problem during the detail design and construction phases. In the transition period when the technical responsibility for the ship moves from the SHAPM to the Ship Logistics Manager, who uses the technical codes as the principal agents for ongoing technical control, the information gap and lack of engineering continuity created could be a problem.

Cost. There are three facets to the cost of the program:

(1) the cost of the process of validation and verification.

(2) the administrative cost of accounting for and controlling revisions to validated documentation.

(3) the cost of work generated by revisions impacting the planned construction process.

Anticipated savings tending to offset these costs include:

(1) the improved construction efficiency resulting from the timely availability to follow shipbuilders of proven drawings and material lists.

(2) the reduced detail design effort by each follow shipbuilder.

Of the five categories of cost and savings named above, only two, the administrative cost of accounting for and controlling revisions to

validated documentation and the cost of work generated by revisions impacting the planned construction process, are being accounted for and reported on a continuing basis. At the time the research for this report was conducted the government and the shipbuilders had identified and reached agreement on the costs for approximately forty percent of the revisions anticipated for the first flight of follow ships. If the trend of these agreements were to continue, it could be projected that the total for these two categories of cost will be less than 1% of the contract costs. However, it is probable that the revisions of least complexity (and cost) were negotiated first. Therefore, cost projections made on this early experience are probably unreliable.

Historically, the rip out and rework required to correct design errors has been a major element of ship construction cost growth above initial estimates. These have been prominent among causes alleged for government responsible delays and disruption in shipbuilder claims. There is no way to determine the cost savings which may have accrued from mistakes not made. An analysis of the cost aspects of the various contracts after close out, however, would probably give some insight.

The cost of the actual validation and verification process is part of the detail design and SUPSHIP monitoring functions and to date has not been broken out and separately identified. The cost savings attributed to reduced detail design effort by each follow shipbuilder are not documented. It is estimated that the engineering and administrative manpower required by the follow shipyards and the SUPSHIPs to perform the work associated with the Validated Drawing Program is one quarter to one half of that which would have been required to accomplish independent detail designs. On the other hand, the engineering labor expended by the lead shipbuilder and the LDA to accomplish the intensified design QA and the validation process was considerably more than what would have been otherwise expended. It is the opinion of the author that these costs and savings are roughly offsetting in the FFG-7 program. That is to say that the effort (in terms of manpower) expended by the LDA, shipbuilders and the Navy SUPSHIPSs in the validation process approximates that which would have been required for duplicative detail designs by the follow shipbuilders. The product, however, appears to be of much higher quality. The DE-1052 Class shipbuilding program of the past decade was similar to the FFG-7 Class program in its multi-year, multi-follow shipbuilder makeup but without a validated drawing program. Extensive problems with unreliable construction documentation for follow shipbuilders were encountered. A comparison of the results of these programs in the future may be useful, especially in the areas of schedule performance and claims.

CONSIDERATIONS FOR FUTURE APPLICATION

Determining the applicability of the validated drawing concept to a particular acquisition program requires consideration of the total acquisition strategy proposed. The size of the program, method of contracting, type of contract, technological features of the ship, similarities to existing ships and specific objectives of the program must be taken into account. The validated drawing concept is not considered in isolation from these.

The objective of validating drawings is to provide reliable working drawings which follow shipbuilders can use to construct the follow ships. Benefits appear to be greatest in large multiship programs. However, some of the side benefits of a validated drawing program would be obtained in a building program of very few ships, i.e., a reliable configuration baseline, documentation of lessons learned in construction, etc. The minimum number of ships warranting the use of a validated drawing program should be determined by an analysis of program objectives and alternate ways for their achievement.

For a validated drawing program to be applicable to and workable in any ship acquisition, the the acquisition strategy of that program must provide for:

a. A multi-ship program with an objective of minimizing the differences between ships.

b. A time interval between lead and follow ship great enough to ensure that physical verification of drawings can occur on the lead ship or a land based test site before their validation to follow shipbuilder.

c. An intensive equipment/component standardization program.

d. A disciplined configuration control system.

e. Lead shipyard services to any follow yard(s) which facilitate the direct physical exchange of design documents and information.

f. Clear, explicit contract language which conveys the intent as well as procedures to be practiced in the validated drawing program.

The most critical element in determining the applicability of the validated drawing concept to a particular ship acquisition is the schedule relationship provided in the acquisition strategy between the lead and follow ship construction. The major considerations in establishing the time interval are the construction period required and previous experience in construction and testing the particular ship under study. Ideally, the interval would allow for the testing of each system on the lead ship before the detailed

construction drawings for each system were needed to construct the follow ship. This ideal interval, from the validated drawing point of view, is frequently in conflict with other objectives of a program such as desired delivery dates, construction methods, equipment procurement schedules, production manning buildups and many other aspects of an acquisition program. These conflicts force compromises in desired schedules. As a result, it is impractical to state proven criteria for determining the lead/follow schedule relationship. Based on the experience in the FFG-7 Class program, however, it is recommended that the time between the planned delivery of the lead ship and first follow ship using validated drawings be at least 30 months for combatant ship types which have concurrent component and/or system development programs.

In assessing the applicability of the validated drawing concept to future ships acquisition programs, it would be highly desirable to know the potential costs and cost savings. Realistically, the cost savings expected can only be partially determined. The savings for elimination of duplicative design efforts can be estimated. However, the major savings -- those coming from the improved efficiency resulting from the utilization of proven drawings -- cannot be estimated. Such an estimate would amount to a judgment as to the savings from mistakes not made. In view of this fact, it is recommended that no attempt at cost/effectiveness analyses be made in assessing the applicability of validated drawings to future ship acquisition programs. In lieu thereof, the benefits and disadvantages of alternative ways of providing reliable detail drawings to follow shipbuilders should be weighed against those of the validated drawing concept without attempting to establish cost/effectiveness criteria.

RECOMMENDATIONS FOR MINIMIZING POTENTIAL PROBLEMS ASSOCIATED WITH FUTURE PROGRAMS OR THE CONTINUING FFG-7 CLASS VALIDATED DRAWING PROGRAM

The FFG-7 Class Validated Drawing Program has been an evolutionary one with the refinements and adjustment in procedures and contractual provisions made in response to changing needs. The procedures and contractual provisions currently in effect are adequate at this time for program implementation. The following considerations and recommendations are presented as suggestions to reduce the potential for future misunderstandings or problems.

Consideration 1: Relative Precedence Between Contract Specifications and Validated Drawings

Discussion: The language of the FFG-7 Class contracts consistently reflects the guidance that contract specifications take precedence over validated drawings. However, if any action of the government, overtly or by implication, contradicts this concept, the point might be disputed. The special attention which is given to the recently conceived Validated Drawing Program as contrasted with the routine treatment of specification changes is an example of potential source for such a dispute.

Recommendation: The government should continuously review its actions related to administering a validated drawing program to ensure that no implication can be drawn from its actions that validated drawings supercede the contract specifications.

Consideration 2: Validated Drawing Requirements in Excess of Specification Requirements

Discussion: There have been a number of cases in the FFG-7 program where a validated drawing requirement exceeds a specification requirement. The possibility exists that a shipbuilder in using such a validated drawing could incur a higher cost that would have been necessary if he had elected not to use it and meet the specification in a different way. In such a case the possibility exists that the shipbuilder would request a contract price adjustment based on the premise that he bid with the lesser cost method in view but used the Navy's warranted validated drawing.

Recommendation: In any case where validated drawing requirements exceed contract specification requirements, the government should expeditiously review both, determine the correct one and contractually execute the change necessary to resolve the discrepancy.

Consideration 3: NAVSEA Technical Codes Participation

Discussion: There is no plan in effect to systematically involve NAVSEA technical codes in the FFG-7 Class Validated Drawing Program. Such participation is not necessary for the detail design and ship construction process. However, the technical codes' eventual responsibility as the Navy's principal technical agents for the FFGs during their operational life and their continuing responsibility for upgrading ship specifications for all ships make such involvement highly desirable. The involvement could be effected either through tasking the technical codes to assist the project manager or SUPSHIPS in general technical reviews or in resolving specific technical issues on a continuing basis.

Recommendation: NAVSEA technical codes should be involved in validated drawing programs in a way which provides them with a systematic and continuous input of design lessons learned and technical decision rationale.

Consideration 4: Limits of Validation

Discussion: The question of whether or not drawings and other documents referenced by a validated drawing are also validated is not clearly answered in the present FFG-7 Class contracts. If such references are not validated, the shipbuilders must determine their impact, if any, on the validated drawings. Therefore, the responsibility for meeting the specifications through using the validated drawing could revert to the shipbuilder. A dispute could develop if the Navy takes the position that only those drawings listed on the validation schedule are in fact validated, while the shipbuilders maintain that a drawing cannot be validated unless all data thereon is also validated.

Recommendation: Contract wording should clearly define the validation status of all documents referenced on validated drawings and delineate the attendant responsibilities of the Government and the shipbuilder. For example, an approach to the contract provision could be that all referenced documents without a validation certification which were of contractor origin would not be considered validated where all those of government origin would be so considered.

ADDITIONAL RESEARCH PAPERS

(NO PRESENTATION TIME AVAILABLE)

INCENTIVISING RELIABILITY IMPROVEMENT WARRANTIES

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ABSTRACT

From a customers point of view, warranties seem desirable as a means of improving reliability and reducing system cost. However contractors may be reluctant to provide warranties where an assumption of excessive risk is perceived to exist. Such situations suggest an incentive fee type of warranty, similar in concept to incentive contracts designed to divide risk assumption between the customer and the contractor. Incentive contracts usually employ a linear decrease in fee as cost increases. To carry the incentive concept into the structuring of warranties a different point of view is required, based on the same general concepts of dividing risk assumption. Incentivised reliability warranties provide warranty fee pools as functions of time. This paper defines concepts of incentivised reliability warranties, develops mathematical models of such warranties, and analyzes selected examples. The research is carried out in a stochastic framework, mathematical models providing expected values of costs as functions of time.

BASIC CONCEPTS AND METHODOLOGY

From the point of view of the user, delivery of a piece of equipment is only the beginning of a period over which the equipment is required to function, its lifetime. On the other hand a contractor or supplier may view the delivery as the end of its period of concern with the equipment. These two viewpoints do not represent desirable approaches to equipment acquisition and in actual practice the user and supplier broaden their periods of interest in the equipment, both being involved throughout at least part of the development and the use periods. User involvement in development occurs through design specifications, design reviews, and various acceptance test procedures. Supplier involvement in equipment operation occurs in some form of maintenance agreement to be found in most contracts for equipment acquisition. One way to achieve satisfactory use is by improving the reliability of equipment. However reliability is a difficult quantity to design, being composed of various random features. A supplier often agrees to some level of reliability as part of a contract but in fact the actual level of reliability may be found to differ from specified values once the equipment is operational. In addition, being random, the times to failure of equipment may prove to be considerably short while still falling technically within design specifications.

In recent years there has been an attempt to improve reliability by having the contractor assume the risk of an equipment failure in terms of a warranty on the equipment. The Reliability Improvement Warranty (RIW) concept has received considerable attention and analysis, as typified by the studies reported in (1). One of the main features of an RIW is that it forces a contractor to take a serious view regarding reliability. This is not done in many cases because of the difficulty associated with quantifying reliability in a significant way. Data on reliability are apt to be scarce or inaccurate. The concepts, based on probability theory, seem strange to most management and engineering personnel, and therefore only cursory attention may be paid to contractual specifications in the reliability area. The RIW makes reliability considerations important from a monetary point of view, acting as a form of penalty against profits should the equipment need to be repaired or replaced during the warranty period.

From the users point of view the RIW has two important features. It focuses the contractor on reliability considerations which are likely to improive the operational status of equipment, and requires the contractor to share the risk of failing to achieve a satisfactory level of operation.

The RIW concept introduces two possibilities for generalization. Though it is desirable from the users point of view, contractors may be very reluctant to assume the full level of risk implied in a normal warranty contract. This leads to the consideration of various incentive forms of warranties in which the risk can be shared between the contractor and the user. Furthermore in such situations there can exist the possibility of additional profit for the contractor when high reliability is achieved. Since such achievement is often the major goal of the user as well, he has a strong motivational instrument in the properly structured incentive warranty. The other direction of generalization is to the concept of availability which, in fact, is most often the users concern rather than purely reliability alone. Equipment failure can often be tolerated so long as down time is sufficiently short and the time between failures satisfactorily long.

This paper studies the concept of incentivisation of warranties for the reliability and more generally, availability situations. The methodology is based on mathematical models of warranty contract structures in a stochastic framework.

Introduction. Incentive type contracts have been in use for some time. They are designed to motivate a contractor to keep cost low, meet schedules, or achieve high levels of performance. The most common form of incentive contracts provide for a fee that decreases with increasing cost. In some cases the decrease may reach to a negative fee (penalty), whereas other forms of contract limit the decrease. Most often the decrease in fee is linear or consists of a few linear segments differing in their rate of decrease. Incentive contracts, in their various forms, have been studied extensively and widely applied. Theoretical analysis of such contract forms may be found in (2) and (3).

The incentive fee concept was developed as an instrument for causing the contractor to assume part of the risk in situations where cost was difficult to determine. Incentivised contracts fall between fixed fee situations where costs should be deterministic and purely research type areas where cost plus fixed fee contracts are required before a contractor will engage in the necessary work. Thus it is the relative uncertainty of cost that makes an incentive fee contract desirable to both contractor and customer. Such concepts may be applied to the reliability/availability situation. If the availability profile of a piece of equipment was deterministic a contractor could figure a meaningful addition to cost for including a warranty. At the other extreme, if the availability behavior was completely erratic no contractor would be willing to provide a warranty. Thus the RIW situation can only be agreed to when a contractor believes he can correctly estimate the availability profile and include sufficient cost to compensate his assumption of the warranty. This situation may not be expected to occur too often, particularly if the contractor fully understands the random character of availability. However the use of incentives described above suggests a method for greatly enlarging the range of situations in which a contractor may engage in a warranty. Rather than having only the two extreme situations of: no warranty, with user assuming all the risk, and normal warranty, with contractor assuming all the risk, the incentivised warranty allows a distribution of risk assumption between user and contractor.

To carry over the incentive concept into the structuring of warranties a different point of view is required, though still following the same general principle of dividing risk assumption. Incentivising reliability warranties is achieved by providing a warranty fee pool as a function of time. Use of an increasing fee pool provides the incentive for a contractor to assume the risk involved in a warranty situation by sharing risk with the customer. An increasing fee pool motivates the contractor to increase time between failures as much as possible which is one major feature of high availability. It is also possible for the contractor to achieve additional profit under a properly structured incentivised warranty. However such situations must be treated very carefully to prevent motivating the contractor to allow failure, which is counter to a major feature of high availability i.e. few failures. A major reason for the detailed mathematical analysis of incentivised availability warranties is to clearly define the various features implicit in such relatively complex contract structures and to quantify, within postulated stochastic frameworks, the levels and forms of incentivisation that will provide desirable availability profiles at a cost agreeable to both the contractor and the customer.

Definitions and Terminology. The mathematical models will consider the payment by the contractor under its warranty obligation as a stochastic process taking place over the warranty period. The models considered in this paper will deal with situations in which a failure causes a payment "c" to be made by the contractor at the time of failure. This may represent replacement or repair costs. The time for making repairs or replacements is not considered in these models. It can be assumed to be relatively short with respect to the full warranty period. The present models are intended to give some basic insights into the incentive warranty concept and it seems undesirable to include the complications of repair/replacement times in these initial models.

In a stochastic availability model the number of times an equipment fails in the warranty period is a discrete random variable. A general model can be made with this point of view. One form of such a model is discussed in (4). However for the purpose of gaining insight into the incentive warranty concept such general models are far too complex. The mathematical and stochastic features of the general model tend to overshadow the details of particular interest in studying the incentive concept. Therefore this paper employs simplified models in which at most one or at most two failures can occur within the warranty period. The one or two failure type models contain the concepts necessary to study incentivised warranties and in many practical situations (though certainly not all) at most two failures may be expected in a reasonable warranty period. Additional analysis of these two cases as well as more general cases may be found in (4). The case of at most one failure in the warranty period is the reliability case. Its study constitutes an extension of the RIW to incentivised forms.

The warranty period is denoted by T^*. It is a contract parameter which specifies the duration of the contractors obligation for assuming correction of failures under the warranty. The warranty fee pool, denoted by $W(t)$ is an amount of money that the customer will provide toward the repair replacement cost for a failure at time t. The fee pool forms employed in this study are of linear segment type. They can most simply be described in the one failure (reliability) case.

The linear segment form in the one failure case is:

$$W_1(t) = a_o \qquad 0 \le t \le t'$$
$$= a_o + b(t-t'), \qquad t' \le t \le T^*$$

where a constant pool value a_o is provided for part of the warranty period, specified by t', and the remaining amount increases linearly at a rate measured by b. This type of warranty fee pool is specified by three parameters (contract parameters): a_o, b, t' and represents a reasonable form for such a pool. It is selected because of its desirability as an actual form rather than for any mathematical convenience. Other warranty pool forms might be employed, for example one based on exponential type functions. However it is felt that the linear segment type is best suited for contract negotiations and for sound intuitive understanding of the features implicit in incentive warranty structures.

For more than one failure the fee pool W(t) becomes a stochastic process. Each time there is a failure some kind of adjustment must be made in W(t) to account for this occurrence. The treatment employed in this study is as follows:

Let $w_k(t)$ denote the warranty fee pool function after k failures. In this notation $w_o(t) = W_1(t)$ defined above. If the first failure occurs at t_1 then

$$\begin{aligned} w_1(1) &= 0 &&, t < t_1 \\ &= w_o(t_1) - c &&, t_1 \le t \le' + t_1 \\ &= w_o(t_1) - c + b(t-t_1-t'), && t'+t_1 \le t \le T^* \end{aligned}$$

Should t' exceed the remaining time T^*-t_1 then $w_1(t)$ has the constant value $w_o(t_1) - c$ over the remaining period. If the second failure occurs at t_2 then:

$$\begin{aligned} w_2(t) &= 0 &&, t \le t_2 \\ &= w_1(t_2) - c &&, t_2 \le t \le t' + t_2 \\ &= w_1(t_2) - c + b(t-t_2-t'), && t' + t_2 \le t \le T^*. \end{aligned}$$

The random nature of the failure events is determined by the failure time distributions and the number of failures. When there is at most one failure the failure time defines the random characteristics of the model. These studies make use of exponential failure time distribution of the form:

$$P[T \le t] = 1 - e^{-\lambda t},$$

widely used in reliability work and found to represent many actual situations.

The models deal with the stochastic process $A_k(t)$, the payment by the contractor under its warranty obligations when k failures occur. In this notation $A_1(t)$ denotes the reliability case and $A_2(t)$ denotes the simplest case that is of availability type. Analysis of the models considers the expected values $E[A_k(t)]$ and variances $Var[A_k(t)]$ which are taken as the quantities which represent the significant features of incentive warranties. By considering the contract parameters present in the warranty fee pool, the parameters of the underlying failure time distributions, and the form of the process $A_k(t)$ an understanding of the complex warranty structure is obtained.

Scope of Model Methodology. The mathematical models employed in this study are of two types: at most one failure, and at most two failures. Each model employs a specified form of warranty incentive fee pool, and probability distribution of time between failures. The study is limited to a single piece of equipment and its availability profile over a specified warranty period. Correction of failure by replacement or repair is assumed to have fixed cost and to be instantaneous. All of these conditions can, of course, be generalized and it may be of value to do so in subsequent studies. In this initial investigation the objective is not to treat the most general or even the most realistic situations but rather to study the concept of incentivising warranties and consider their generalization from reliability to availability form.

Each model provides an opportunity for analysis designed to show the effect on the payment process $A_k(t)$ due to postulated structure and magnitude of contract parameters defining the incentive pool. These effects must necessarily be studied within postulated random behavior of equipment failure. The results are intended to show how incentivising warranties motivates a contractor to both assume such warranty obligations and provide a desirable level of availability. The analyses of this study constitute a background for understanding the incentivising of availability warranties.

An important consideration in warranties is the value of money. This is because the payment process $A_k(t)$ will take place in the future, often several years after the original contract for development and manufacture of an equipment is negotiated. It has become rather standard practice in studying contract structuring and particularly in RIW research, e.g. in (1), to account for the value of money. The present study is primarily intended as a theoretical investigation of the concepts discussed above. The modifications to true value of money do not effect these theoretical considerations, though they must be considered when using the model analyses as guides for structuring actual incentivised warranties. Such considerations are not included in this paper, however they are discussed to some extent in (4).

AT MOST ONE FAILURE (THE RELIABILITY CASE)

This section defines and analyzes models representing incentivised reliability warranties. At most one failure is allowed in these models. The reliability case fee pool has the form:

$$W(t) = a_o \quad , \quad 0 \leq t \leq t'$$
$$= a_o + b(t-t'), \; t' \leq t \leq T^*.$$

The analyses develop expressions for $E[A_1(t)]$ and $Var[A_1(t)]$, the expected value and variance of the contractor payment process $A_1(t)$ in the case of at most one failure. Expected values are computed using condition type logic of the form: For a random variable X defined over an interval (O, R) with distribution function $F_X(x)$

$$E[X] = \int_0^R x\,d F_X(x) = \int_0^{R_1} x\,d F_X + \int_{R_1}^R x\,d F_X$$

where $0 < R_1 < R$. Thus in dealing with the linear segment fee pool differing payment forms are divided into appropriate segments for computing expected values.

Here $$A_1(t) = 0 \quad , \quad t < T$$
$$= c - W(T), \; T \leq t \leq T^*$$

where the random variable T is the failure time governed by a probability density function $f_T(t)$.

In the following development of basic formulas P[ ] denotes the probability expression and a vertical line, indicates conditional expressions.

$$E[A_1(t)] = E[A_1(r) | t < T] \, P[t < T]$$
$$+ E[A_1(t) | t \geq T] \, P[t \geq T].$$

Since $E[A_1(t) | t < T] = 0$ it follows that:

$E[A_1(t)] = E[c - W(t) | t \geq T] \, P[t \geq T]$, or using the density function $f_T(t)$:

$$E[A_1(t)] = \int_0^t [c - W(v)] f_T(v) dv.$$

Considering the expression for variance gives:

$$Var[A_1(t)] = \int_0^t \left(c - W(v)\right)^2 f_T(v) dv - \left(E[A_1(t)]\right)^2.$$

Deterministic Failure. When the failure occurs at a specified time s with probability one the deterministic failure model results. In this case:

$$E[A_1(t)] = 0 \quad , \quad t < s$$
$$= c - a_o \quad , \quad t \geq s \text{ and } s < t'$$
$$= c - a_o - b(t-t'), \quad T^* \geq t \geq s \text{ and } s \geq t'$$

$Var[A_1(t)] = 0$ for all t.

The action of the incentive fee pool is obvious in this case. So long as $a_o + b(T^* - t') < c$ failure will cost the contractor money. It will cost less when it occurs further along in the warranty period. This may be considered the classical situation from the customers point of view. However the cost reduction, without an actual profit motive might not be enough to make such a contract attractive to the contractor. On the other hand there is no risk assumption in this simple case. The failure time is known exactly and therefore specifies a known payment requirement. Since the opportunity for profit should imply a degree of risk assumption on the part of the contractor it would be meaningless to include such a possibility $(a + b(T^* - t') > c)$ in this simple case. When the failure time is uncertain, as it most often is in practice, more possibilities exist.

Exponential Failure. In the models described in this section the incentive fee pool is the linear segment type. The failure time probability density function has the form:

$$f_T(t) = \lambda \, e^{-\lambda t} \quad , \quad t \geq 0$$
$$= 0 \quad \text{elsewhere.}$$

In this model there is always some non-zero probability of the failure event occurring after the end of the warranty period, designated by T^*. Therefore the expected values are computed as functions of the evaluation time t, never yielding the full expectation over all non-zero failure events. The payment process $A_1(t)$ ends at T^* and by setting it to zero for $t > T^*$ one can interpret the expected value formulas (including variance) given below as being completed by the time t reaches T^*. In this interpretation, though the expected values are completed the probability of zero payment is not zero but is equal to the probability density remaining after the expiration of the warranty. Denote the probability of zero payment by P_o then:

$$P_o = \int_{T^*}^{\infty} \lambda \, e^{-\lambda t} dy = e^{-\lambda T^*}$$

this is a useful quantity in the exponential failure models. A similar quantity can be defined in any model assigning non-zero probability density to time events after T^*. Direct calculation yields:

$$E[A_1(t)] = (c - a_o)(1 - e^{-\lambda t}), \quad 0 \leq t \leq t'$$
$$= (c - a_o)(1 - e^{-\lambda t}) + b(t - t') \, e^{-\lambda t}$$
$$+ \frac{b}{\lambda}(e^{-\lambda t} - e^{-\lambda t'}), \quad t' \leq t \leq T^*.$$

The term $(c - a_o)(1 - e^{-\lambda t})$ is the expected contractor cost with only a constant incentive a_o provided by the customer. The remaining expressions represent the contribution of the increasing incentive pool values to the contractors payment process

under its warranty obligations. If the incentive is to be effective these terms should be negative for all $t > t'$ thereby reducing payment that may occur at time before the evaluation time t. The sign of these terms is determined by the sign of the expression:

$$\lambda(t-t') + 1 - e^{-\lambda(t'-t)}$$

which may be shown to be negative for all t as required. Moreover the expression becomes increasingly negative as t increases as it should for proper incentive structure.

To compute $Var[A_1(t)]$ one requires $E[A_1^2(t)]$:

$$E[A_1^2(t)] = (c-a_o)^2 (1-e^{-\lambda t}), \qquad 0 \leq t \leq t'$$

$$= (c-a_o)^2 (1-e^{-\lambda t'}) - \left[(\alpha - bt - \frac{b}{\lambda})^2 + \frac{b^2}{\lambda^2}\right] e^{-\lambda t}$$

$$+ \left[(\alpha - bt' - \frac{b}{\lambda})^2 + \frac{b^2}{\lambda^2}\right] e^{-\lambda t'}, \quad t' \leq t \leq T^*$$

where $\alpha = c - a_o + bt'$.
This expression indicates a complicated form for $Var[A_1(t)]$ in the exponential case. Because of this complexity the variance is not formulated in this study. However the special case where $t'=0$, with no constant fee pool period may be considered. This is the true incentive case of most interest and the results, while not particularly simple, are reasonable.

In the case $t'=0$, $\alpha = c-a_o$ and there is only one range of definition, $(0, T^*)$, for the functions developed.

$$E[A_1(t)] = (c-a_o - \frac{b}{\lambda}) - (c-a_o - \frac{b}{\lambda} - bt)\, e^{-\lambda t}$$

$$Var[A_1(t)] = \frac{b^2}{\lambda^2} + \left[(c-a_o - \frac{b}{\lambda})^2 - b^2 t^2 - \frac{b^2}{\lambda^2}\right] e^{-\lambda t}$$

$$- (c-a_o - \frac{b}{\lambda} - bt)^2\, e^{-2\lambda t}$$

Consider the end value, at $t=T^*$, which measures the expected payment if a failure occurs within the warranty period. For simplicity the case $t'=0$ is presented:

$$E^* \equiv E[A_1(t)] = (c-a_o - \frac{b}{\lambda})(1-e^{-\lambda T^*}) + bT^* e^{-\lambda T^*}$$

If instead of a warranty period of duration T^* a lifetime maintenance was assumed by the contractor, with the same kind of incentive pool and one failure assumed, the resulting expected payment will be:

$$E^\infty = c-a_o - \frac{b}{\lambda}\,.$$

Of course it is unrealistic to have a continually increasing, unbounded fee pool. However such an assumption is useful here for simplicity and is appropriate because the probability of failure decreases strongly as time increases. The combined effect is for a reasonable expected value, as given above.

The quantity $E^\infty - E^*$ represents the difference in payments by the contractor under lifetime maintenance and warranty type contracts. Of course the major assumptions are at most one failure, and the same incentive fee pool. Though somewhat unrealistic as practical contract assumptions, this illustration gives an idea of one methodological approach for comparing different maintenance concepts.

$$E^\infty - E^* = [bT^* - (c-a_o - \frac{b}{\lambda})]\, e^{-\lambda T^*},$$

and depending on the parameter values different situations may be considered. A case of some interest occurs when the factors effecting the payment: failure distribution, and fee pool form, are such as to give the same expected payment with both methods. This occurs when $E^\infty - E^* = 0$ or:

$$bT^* = c-a_o - \frac{b}{\lambda}$$

A result such as this indicates the interrelation of contract parameters, a_o, b, T^*, replacement cost c, and failure distribution parameter λ. To the extent that such expressions could be developed (even in tabular form for complicated situations) to represent actual situations, they would be useful negotiation tools.

Discussion. The payment by the contractor under an incentive warranty is a stochastic process of simple type, defined as:

$$A_1(t) = \begin{cases} 0, & T > t \\ c-a_o, & T \leq t', \quad T \leq t \leq T^* \\ c-a_o + bt' - bT, & T > t', \quad T \leq t \leq T^* \\ 0, & T > T^*. \end{cases}$$

The actual payment is, in any case, a numerical value determined by the time at which the random failure event takes place, denoted by the random variable T. Thus $A_1(t)$ is a step function of t with the step location determined by T and the step height determined by the fee pool value at the time the step occurs.

In motivating the contractor to increase the time to failure by providing an increasing fee pool there is a danger that the contractor will desire a failure toward the end of the warranty period so as to receive incentive fee. This undesirable situation can be prevented by selecting contract parameters so that $c-a_o + bt' - bT^* > 0$ so that any failure will actually cost the contractor money.

There is another point of view however that considers the provision of an incentive warranty fee pool insufficient inducement for the contractor to

agree to a warranty. It is true that its risk of payment is reduced, but with the condition of possible negative payment the warranty still represents a (randomly specified) cost to the contractor. Therefore there is a problem with the basic approach: in order to avoid the counter motivation of wanting a failure the chance for obtaining profit by agreeing to a warranty is lost. One way to combine the desired motivation is to agree to an award fee of some kind if no failure occurs by the end of the warranty period. A reasonable value for such an award fee might be $a_o - bt' + b T^*$, the value reached by the incentive fee pool by the end of the warranty period. If availability is a major concern to the customer, with savings in money a secondary consideration, then a substantial award fee suggests itself. In the combined incentive warranty pool, award fee concept the contractor is motivated to assume the warranty obligation by the chance of profit and motivated to design for long operating times (in the at most one failure case).

In previous sections the payment process $A_1(t)$ is characterized by the expected payment up to time t and by the variance of the process. These expressions may be useful for planning before the start of the warranty period and as management decision tools during the warranty period. Of course once the failure occurs the payment is known exactly and the process $A_1(t)$ ceases to represent the payment. The effectiveness of the models and their formulas for expected value and variance for planning and control purposes depends to some extent on the time scales involved. When the warranty period is long the change in expected payment over time can be a valuable planning tool, particularly when the necessary payments under the warranty are large. The research described in this paper is directed toward developing a methodology for studying the concepts of incentivising warranties. Further discussion and analysis may be found in (4).

AT MOST TWO FAILURES

Formulation of the Model. When more than one failure can occur many new features may be introduced into the warranty payment model. The material in this paper represents an initial formulation of the incentive warranty structure and as such it treats a rather simple model. The payment process $A_2(t)$ is taken as the mathematical model for the incentive warranty structure. The expected value and variance of $A_2(t)$ are calculated as being the representational quantities of interest. However it should be noted that one could also consider the probability that $A_2(t)$ has some particular property e.g. $P[A_2(t) \le k]$ might prove to be of value in the study of process $A_2(t)$.

The incentive fee function is assumed to be a linear function having constant slope b. If T_1 and T_2 represent the random variables: time to first and second failures, respectively, then the payment process for at most two failures has the form:

$$A_2(t) = c - bT_1 + c - b(T_2 - T_1).$$

The One Random Variable Approach. An approach to the study of the process $A_2(t)$ is in terms of the single random variable T_2, the time (starting from zero) to the second failure event.

The process $A_2(t) = c - b\,T_1 + c - b(T_2 - T_1)$ can be written more simply as:

$$A_2(t) = 2c - bT_2.$$

To study $A_2(t)$ in terms of the random variable T_2 the probability density function $f_{T_2}(v)$ is required. Since $T_2 = R_1 + R_2$, where R_1 and R_2 are independent exponential random variables with $\lambda_1 \neq \lambda_2$, the joint density can be used to obtain the distribution function:

$$F_{T_2}(v) = P\left[R_1 + R_2 \le v\right] = 1 - e^{-\lambda_2 v} + \frac{\lambda_2}{\lambda_2 - \lambda_1}\left(e^{-\lambda_2 v} - e^{-\lambda_1 v}\right).$$

Differentiation and arrangement of terms results in:

$$f_{T_2}(v) = \frac{\lambda_1\lambda_2}{\lambda_2 - \lambda_1}\left(e^{-\lambda_1 v} - e^{-\lambda_2 v}\right).$$

Partial expectations of T_2 restricting $v \le t$ are used to obtain expectations for $A_2(t)$.

Let $E_t[T_2]$ denote the partial expectation of T_2, restricting v to: $v \le t$. Then:

$$E_t[T_2] = \frac{\lambda_1\lambda_2}{\lambda_2 - \lambda_1}\int_0^t v\left(e^{-\lambda_1 v} - e^{-\lambda_2 v}\right)dv$$

$$E_t[T_2] = \frac{\lambda_1\lambda_2}{\lambda_2 - \lambda_1}\left[\frac{1}{\lambda_1^2} - \frac{1}{\lambda_2^2} + t\left(\frac{e^{-\lambda_2 t}}{\lambda_2} - \frac{e^{-\lambda_1 t}}{\lambda_1}\right) + \frac{e^{-\lambda_2 t}}{\lambda_2^2} - \frac{e^{-\lambda_1 t}}{\lambda_1^2}\right]$$

Then $E[A_2(t)] = 2c\,P[T_2 \le t] - b\,E_t[T_2]$, which gives:

$$E[A_2(t)] = 2c\left\{1 - e^{-\lambda_2 t} + \frac{\lambda_2}{\lambda_2 - \lambda_1}\left(e^{-\lambda_2 t} - e^{-\lambda_1 t}\right)\right\} - \frac{b\lambda_1\lambda_2}{\lambda_2 - \lambda_1}\left\{\frac{1}{\lambda_1^2} - \frac{1}{\lambda_2^2} + t\left(\frac{e^{-\lambda_2 t}}{\lambda_2} - \frac{e^{-\lambda_1 t}}{\lambda_1}\right) + \frac{e^{-\lambda_2 t}}{\lambda_2^2} - \frac{e^{-\lambda_1 t}}{\lambda_1^2}\right\}.$$

To obtain $E[A_2^2(t)]$ and hence $Var[A_2(t)]$ the expression $E_t[T_2^2]$ is required:

$$E_t[T_2^2] = \frac{\lambda_1\lambda_2}{\lambda_2-\lambda_1}\left\{-\frac{t^2}{\lambda_1}e^{-\lambda_1 t} + \frac{2}{\lambda_1^3} - 2\left(t+\frac{1}{\lambda_1}\right)\frac{e^{-\lambda_1 t}}{\lambda_1^2}\right.$$

$$\left. + \frac{t^2}{\lambda_2}e^{-\lambda_2 t} - \frac{2}{\lambda_2^3} + 2\left(t+\frac{1}{\lambda_2}\right)\frac{e^{-\lambda_2 t}}{\lambda_2^2}\right\}.$$

$$E[A_2^2(t)] = E_t[4c^2 - 4bcT_2 + b^2T_2^2]$$

$$= 4c^2 P[T_2 \le t] - 4bc E_t[T_2] + b^2 E_t[T_2^2]$$

$E[A_2^2(t)] = D_1 + D_2 + D_3$, where

$$D_1 = 4c^2\left[1 - e^{-\lambda_2 t} + \frac{\lambda_2}{\lambda_2-\lambda_1}\left(e^{-\lambda_2 t} - e^{-\lambda_1 t}\right)\right],$$

$$D_2 = \frac{-4bc\lambda_1\lambda_2}{\lambda_2-\lambda_1}\left[\frac{1}{\lambda_1^2} - \frac{1}{\lambda_2^2} + t\left(\frac{e^{-\lambda_2 t}}{\lambda_2} - \frac{e^{-\lambda_1 t}}{\lambda_1}\right)\right.$$

$$\left. + \frac{e^{-\lambda_2 t}}{\lambda_2^2} - \frac{e^{-\lambda_1 t}}{\lambda_1^2}\right],$$

$$D_3 = \frac{b^2\lambda_1\lambda_2}{\lambda_2-\lambda_1}\left[-\frac{t^2}{\lambda_1}e^{-\lambda_1 t} + \frac{2}{\lambda_1^3} - 2\left(t+\frac{1}{\lambda_1}\right)\frac{e^{-\lambda_1 t}}{\lambda_1^2}\right.$$

$$\left. + \frac{t^2}{\lambda_2}e^{-\lambda_2 t} - \frac{2}{\lambda_2^3} + 2\left(t+\frac{1}{\lambda_2}\right)\frac{e^{-\lambda_2 t}}{\lambda_2^2}\right].$$

These expressions can be used to give the variance in the form:

$$\mathrm{Var}[A_2(t)] = E[A_2^2(t)] - \left(E[A_2(t)]\right)^2.$$

The only way to consider such complex expressions is as numerical functions of t. This kind of detailed calculations is outside the scope of this paper, however the case where $t \to \infty$ can be calculated directly. This yields:

$$E[A_2] = 2c - b\left(\frac{1}{\lambda_1} + \frac{1}{\lambda_2}\right)$$

$$\mathrm{Var}[A_2] = b^2\left[\frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}\right].$$

Limits as Failure Rates Become Equal. Both $E[A_2(t)]$ and $\mathrm{Var}[A_2(t)]$ may be found for the case $\lambda_1 = \lambda_2 = \lambda$. The expressions in question are simple functions of the failure rates λ_1 and λ_2 and the limit as $\lambda_1 - \lambda_2 \to 0$ certainly exists.

The limit calculations yield:

$$\lim_{\lambda_2-\lambda_1\to 0} E[A_2(t)] = 2c - \frac{2b}{\lambda} + \left[2b\left(\frac{1}{\lambda} + t + \frac{\lambda t^2}{2}\right)\right.$$

$$\left. - 2c(1+\lambda t)\right]e^{-\lambda t}$$

$$\lim_{\lambda_2-\lambda_1\to 0} \mathrm{Var}[A_2(t)] = \frac{2b^2}{\lambda^2} + \left[4c^2 - \frac{8bc}{\lambda} + \frac{2b^2}{\lambda^2}\right.$$

$$\left. + \left(4c^2\lambda - 8bc + \frac{2b^2}{\lambda}\right)t + b^2t^2 - b^2\lambda t^3\right]e^{-\lambda t}$$

$$+ \left[2b\left(\frac{1}{\lambda} + t + \frac{\lambda t^2}{2}\right) - 2c(1+\lambda t)\right]^2 e^{-2t}$$

Limits as the Second Failure Rate Increases. If λ_2 becomes large the time between the first and second failures reduces in a probabilistic sense. In the limit as $\lambda_2 \to \infty$ the two failures occur together. In this case the results should agree with the one failure model except that the cost parameter becomes 2c corresponding to the fact that there are actually two failures, or double the cost, at the combined failure time. Evaluation of this limit case serves as a check on the single and double failure models. Direct calculations show that:

$$\lim_{\lambda_2\to\infty} E[A_2(t)] = E[A_1(t)].$$

$$\lim_{\lambda_2\to\infty} E[A_2^2(t)] = E[A_1^2(t)].$$

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AFFORDABILITY FOR MAJOR SYSTEM ACQUISITIONS

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ABSTRACT

The objective of this study was to develop a management approach for addressing the affordability problem in the procurement funding area. It was concluded that affordability determinations must be the responsibility of the PPBS resource allocation process because affordability deals principally with the question of how to allocate finite budget resources to competing programs. DSARC's role in affordability should be supportive of the PPBS. It was also concluded that there is a need to establish a 15-year baseline procurement program for each Military Department. It was recommended that OSD develop an affordability analysis procedure for each Service to use in establishing its own 15-year baseline procurement program. Such a procedure was developed, based on the use of an affordability matrix for the procurement appropriations of each Military Department. It allocates forecasted procurement resources to programs for a 15-year period based on program priority and cost, thereby establishing a 15-year baseline procurement program for each Department.

INTRODUCTION

THE AFFORDABILITY PROBLEM

DoD financial planning guidance prescribes only a 2.7 percent real growth rate per year for future appropriations, but more systems are being developed and produced than the anticipated budgets will accommodate.(1) A recent GAO report indicated that it would require approximately $72.5 billion annually for the next 10 years just to complete procurement of the DoD systems currently in development or production. (2) Fiscal year 1979 military procurement appropriations totalled approximately $31 billion. It is clear that the DoD realistically cannot afford to complete some programs already in existence.

In the past, the DoD has emphasized improvements in estimating program costs and in keeping those costs within the estimates. Insufficient effort has been devoted to deciding in advance the amount the DoD can afford to spend to satisfy mission needs within each mission area, prioritizing the individual mission elements, and then establishing an affordable plan for satisfying those needs.

A traditional solution to the problem of more requirements than resources has been to stretch out programs by deferring some of the funding. This has enabled most ongoing programs to continue. Such deferrals, however, have produced undesirable consequences, including:

- inefficient and uneconomical rates of production
- large program cost increases
- equipment inventory shortages
- long acquisition cycles
- delays in fielding new equipment
- adverse DoD relationships with Congress, industry and the public

In addition, program funding deferrals have created a growing backlog of ongoing programs in need of procurement funds in order to be completed. This backlog sometimes is called the "acquisition bow wave."

The situation just described is known as the affordability problem. Affordability has been defined as "the ability to provide adequate resources to acquire and operate a system."(3) At present, DoD does not have a definitive plan for addressing the problem. Questions of affordability are now raised in the Defense Systems Acquisition Review Council (DSARC) and Planning, Programming, and Budgeting System (PPBS) processes. Affordability is also a topic of increasing Congressional interest.

THE NEED FOR CONSIDERATION OF AFFORDABILITY

The need for consideration of affordability in major system acquisition was recognized by the Defense Science Board (DSB) in its Report of the Acquisition Cycle Task Force, March 15, 1978. It concluded that "the basic reason for the lengthening of the production phase is that there are simply more programs ready to enter the production phase at any given time than there are production funds available to fund them." The DSB recommended that the DoD "fund fully only that number of the most critically needed programs so that the resources required will be within the Congressional budget limitations." Those "affordable" programs would be the only ones for which the Mission Element Need Statement (MENS) would be approved at Milestone 0.

A preliminary concept for addressing affordability has been drafted by the Office of the Under

Secretary of Defense, Research and Engineering (OUSDRE). Included in that concept are such issues as program priority within a mission area and the influence of short and long-term budgetary constraints on program decisions.

The primary objective of this study was to develop a management approach for addressing the affordability problem in procurement funding, giving due consideration to current OSD initiatives. A second objective was to quantify the magnitude of the affordability problem in the procurement area using data on actual DoD programs. As the DSB made clear in its report quoted above, the procurement funding area is where the affordability problem is most acute. It is recognized that consideration of affordability should embrace all funding categories (research and development, procurement, operation and support); nevertheless, a method for addressing affordability in procurement funding alone should be a significant contribution to solving the affordability problem.

FINDINGS

THE MAGNITUDE OF THE AFFORDABILITY PROBLEM

To quantify the magnitude of the affordability problem in the procurement area, requirements (i.e., forecasted program procurement costs) were compared with resources (i.e., forecasted procurement appropriations) for the Army, Navy and Air Force. The requirements data were extracted from each Military Department's Extended Planning Annex (EPA) to its fiscal 1980 Program Objective Memorandum (POM). Resource data were developed by applying assumed annual real growth rates of 1, 2, and 3 percent to actual procurement appropriations for fiscal 1979. Those growth rates were chosen in light of current fiscal guidance, the historical lack of significant real growth in procurement funds, and the increasing share of total funds needed for operation and support at the expense of procurement. Due to the classified nature of certain data, detailed findings are not presented herein. General findings are discussed below.

Both the Army and the Navy have a large potential affordability problem in the procurement area throughout the entire fiscal 1980 to 1994 period, irrespective of the assumed annual real growth rate used to forecast "outyear" procurement appropriations. ("Potential affordability problem" means that estimated program procurement costs exceed forecasted procurement appropriations.) The Air Force, on the other hand, does not have a potential affordability problem except for the period fiscal 1990 through 1994, assuming 2 percent annual real growth in procurement appropriations, and except for the period fiscal 1986 through 1994, assuming 1 percent annual real growth in procurement appropriations. The potential affordability problems for the Army and Navy are so large that shifting any potential Air Force excess appropriations would do little to ease them. Therefore, DoD as a whole is faced with a large and ever-increasing potential affordability problem.

Although the procurement cost estimates used in this analysis do not take into account such factors as potential cost growth or program cost estimating inaccuracies, such factors have been and continue to be a reality. It is likely that the programs included in this analysis will experience cost growth, thereby exacerbating the affordability problem. Clearly, there is a great disparity between requirements and resources in the DoD, and more systems are being developed and produced than anticipated future budgets will support.

FACTORS CONTRIBUTING TO THE AFFORDABILITY PROBLEM

Five major factors contribute to DoD's affordability problem: insufficient interaction between the PPBS and the DSARC, program cost growth, limited period covered by the PPBS, program advocacy, and the downward trend in procurement appropriations.

Insufficient Interaction Between the PPBS and the DSARC. For the most part, the DSARC and PPBS processes operate independently. Existing OSD and Service regulations and instructions do not require any specific interaction between these two processes and, at present, there is very little. PPBS decisions are often made without due regard to their programmatic consequences. The budgeting process focuses on the programs to be funded in the first years of the Five Year Defense Plan (FYDP). There are generally more programs needing funds than there are funds available in any given year. Hence, programs must be cut or altered. This can result in decisions which may appear logical from a budgeting standpoint (e.g., stretching out several programs to stay within immediate year budget constraints) but questionable from a program management standpoint.

Similarly, DSARC decisions are often made without due regard to fiscal constraints. A DSARC review focuses on a particular program and tries to determine the best method for carrying it out from a technical and business perspective. The DSARC pays little attention to the other programs competing for available funds. Therefore, decisions sometimes cannot be fully implemented because of funding limitations.

OSD has addressed the problem of DSARC/PPBS linkage through an affordability policy statement included in the latest draft revision to DoD Instruction 5000.2, "Major System Acquisition Procedures." This instruction now requires that program milestone presentations to the DSARC include:

- "comparison of program resource estimates with latest PPBS projections (including the extended planning annex)"

- "identification of the relative ranking for this and the DoD Component's other major systems in the mission area in the latest program or budget submission"
- "where program cost estimates exceed latest budget projections, identification of potential offsets necessary to provide the resources to execute the remaining phase(s) of the program in the manner recommended to the DSARC"

The policy statement specifies that affordability is principally a determination of the PPBS process, even though the policy impetus comes from those responsible for the acquisition process, not the PPBS process. The absence of such a policy statement from those responsible for the PPBS process may be due to the prevailing view that affordability considerations are inherent in the fiscal constraints and program prioritization used in the PPBS process.

The SecDef Consolidated Guidance to the Military Departments for POM preparation includes limits (called fiscal guidance) on available outyear funding. Program prioritization results from OSD requiring the Services to submit their POMs using three different levels of assumed funding availability, called the minimum, basic and enhanced cases. (The minimum case is the lowest level of assumed funding, and the enhanced case is the highest.) The programs appearing in the minimum case represent the Department's best judgment as to which programs should continue even if overall DoD funding is reduced. Hence, they have a higher priority than the programs only in the basic case, which in turn have a higher priority than those only in the enhanced case. Programs in the basic and enchanced cases are further prioritized during the PPBS process. In practice, programs comprising existing forces tend to be placed in the minimum case. Since operating and support funds are required for such programs, the programs needing procurement funds tend to appear in the basic and enhanced cases. Hence, the procurement programs receive the most discriminating priority ranking.

<u>Program Cost Growth</u>. There have been many major cost increases in DoD system acquisitions. A recent GAO report stated that of the $235 billion in estimated costs for 58 current DoD major acquisitions, $95 billion represents cost growth over the baseline (development) estimates.(4) The Report of the Commission on Government Procurement stated:

> "Entire system costs cannot be estimated realistically during its early development. Institutional arrangements and advocacy pressures tend to drive cost estimates downward and to produce overly optimistic schedule and performance appraisals. All levels in a department, in industry, and even in Congress can become parties to the 'selling' of programs founded on unrealistic and unattainable system cost goals".(5)

Overly optimistic cost estimates used to "sell" a program tend to become the basis for budgeting it. When it becomes obvious that the estimates are low, the program may be stretched out to stay within overall budget constraints, thereby adding to the acquisition bow wave and aggravating the affordability problem.

<u>Limited Period Covered by the PPBS</u>. The primary PPBS document (the FYDP) spans only 5 years, but the acquisition cycle for major weapon systems can extend from 10 to 15 years. The PPBS may not include in the procurement accounts some high priority programs still in the development stage which will not need procurement funds until beyond the FYDP timeframe. When such programs reach the point where procurement funds are needed, ongoing programs may be stretched out to accommodate them.

In theory, the Military Department EPAs should take over where the FYDP leaves off and be the basis for consideration of procurement programs over the 10 years subsequent to the FYDP. EPAs are apparently little used. There is little uniformity in the way they are prepared--perhaps largely due to the lack of OSD guidance or requirements in this matter.

<u>Program Advocacy</u>. It is difficult to cancel a program once it gains momentum and advocacy within a Service, OSD or the Congress. This problem increases once a program gets into full-scale development and approaches a production decision. The DSB in its 1977 Summer Study on the acquisition cycle found that "...with strong advocates, certain programs may be continued in existence long after they should have been terminated for technical problems, inadequate capability, cost or schedule overruns, or similar reasons." To the extent that marginal programs are continued only because of strong advocacy, the affordability problem is intensified.

<u>Downward Trend in Procurement Appropriations</u>. For the past 20 years, the trend in military procurement appropriations, in constant dollar terms, has been downward. The trend in the ratio of procurement appropriations to total appropriations has also been downward for the same period. This history indicates that, despite current initiatives to increase defense spending by an average of 4.5 percent in real terms over the next five years, significant real growth in procurement appropriations is unlikely. Hence, DoD must plan on the basis of a relatively slight growth in outyear procurement resources. Despite this, the Military Departments are not given outyear fiscal constraints on procurement appropriations for use in planning outyear programs. The only constraints are on total appropriations. Thus, a Department can plan for a large real growth in procurement resources in any year, as long as the total of all needed resources stays within the fiscal guidance given it. This contributes to DoD's affordability problem.

CONCLUSIONS

A FRAMEWORK FOR AFFORDABILITY ANALYSIS

Affordability deals principally with the question of how to allocate resources to competing programs. Therefore, affordability determinations must be a responsibility of the PPBS resource allocation process. Affordability cannot be addressed on an individual program basis alone. It must be addressed in terms of all programs competing for the same resources. This is another reason why the PPBS, which considers all resource demands in unison, must be the forum for determining affordability.

Three basic factors determine affordability: program priority, availability of budget resources, and program cost. Affordability analysis must deal simultaneously with all three factors, and try to reconcile available resources with needs. A discussion of the three factors follows:

Priority - Foremost among the factors determining affordability is the relative priority of the programs competing for the same resources. In an environment where there are more requirements (programs) than resources (funding), the requirements must somehow be ranked according to importance so that the limited resources may be properly allocated. Certain DoD programs are absolutely essential because of the urgency and severity of the threat against which they are to be deployed. Their high priority makes them affordable. For such programs, such considerations as operating and support requirements (including manpower) have little bearing on whether or not the program should be pursued. The question relative to the other considerations is how best to minimize their costs without degrading ability to carry out the intended mission. Operating and support considerations may, however, be critical in deciding on the affordability of less essential systems of equal priority if there are insufficient resources to accommodate all of them.

Availability of Budget Resources - Clearly, all systems would be affordable if the available resources were unlimited. Since this is not the case, knowing the amount of resources available is crucial in determining what programs are affordable. Consequently, ability to forecast outyear budget resources is essential to addressing affordability.

Program Cost - The resources needed to accomplish a program are determined on the basis of program cost estimates. Because of the importance of program cost in the determination of affordability, it is imperative that program cost estimating in the Service and OSD be realistic.

Putting the above factors together, an affordable program is one with a high enough priority so that when its estimated costs are added to the estimated costs of all programs with a higher priority, the resulting sum is less than or equal to the forecasted resources available.

Program priorities should be based on an assessment of the need and military essentiality for each program competing for the same resources. They should be consistent with national objectives and policy as represented in promulgations of the National Security Council and the Joint Chiefs of Staff. Current OSD initiatives in the area of NATO rationalization, standardization and interoperability could affect program priorities.

With respect to availability of budget resources, OSD and the Military Departments should take into account the downward trend in procurement appropriations as a percentage of total appropriations when planning for outyears. They should recognize that since outyear planning and programming is based on constrained real growth in the total of all appropriations, experience indicates it is logical to limit the real growth in the procurement appropriations for outyear planning and programming purposes. Also, forecasts of outyear procurement resources should be made in a uniform and consistent manner by all the Departments, and the results should appear logical and realistic in light of past experience.

THE DSARC ROLE IN AFFORDABILITY

The DSARC was established "to advise (DepSecDef) of the status and readiness of each major system to proceed to the next phase of effort in its life cycle."(6) No role in the resource allocation process was contemplated for the DSARC.

The Defense Resource Management Study Final Report by Donald B. Rice, dated February 1979, also addresses the role of the DSARC and its involvement in resource allocation. Specifically, this report states:

- "DSARC was created to 'discipline the acquisition process' by directing top management attention to the critical decision points of important acquisition projects."
- DSARC "was not designed as a parallel resource allocation process; rather, it was to provide for a structured technical and financial management review of a project and 'authorization' for it to proceed, while the PPBS continued to serve the internal 'appropriation' function."
- "The alternative selected by the DSARC (should not) drive the funding profile approved in the programming process."
- "The internal 'appropriation' function - the decision to proceed with a program - should consider its 'affordability' over time in the context of aggregate projections of Defense funding requirements. DSARC decisions should remain permissive authorizations: Proceed if you have, or if you can obtain, the resources needed to continue the project."

The general thrust of the above comments on the DSARC's role in resource allocation is substantially correct. Further, it is noted that the DSARC examines relatively few programs each year. For example, in fiscal 1979 only 13 programs underwent a DSARC milestone review, and for the past 10 years the DSARC has been averaging only 18 to 20 program milestone reviews per year. Moreover, many systems are never reviewed by the DSARC, and the time between DSARC reviews for some programs can exceed five years.

It is concluded that DSARC's role in affordability determinations should be to support the PPBS by continuing to ensure that the decisions made in the PPBS arena on what is to be acquired are carried out in a sound business and technical manner. The DSARC, with its more detailed examinations of a program, also can be supportive of the PPBS by verifying a program's progress at critical points in its life, and by validating program cost estimates which can be used in the PPBS process. Relative to affordability, this role falls short of that contemplated in the latest draft revision to DoD Instruction 5000.2 in the area of ranking programs within mission areas, and identifying potential offsets that may be necessary to provide resources to execute the program.

OTHER CONCLUSIONS

The acquisition bow wave and other problems which necessitate consideration of affordability-related issues could be eased in three ways: increasing the amount of available procurement resources in the outyears; reducing the cost of programs in development and production; and cancelling some lower priority programs. However, as previously indicated, it is unlikely that a significant increase in future DoD procurement appropriations will occur. Thus, actions in this area do not appear to hold much promise relative to easing the affordability problem. Cost reduction efforts in DoD have been numerous and should be continued. However, to date they have not had enough effect on the affordability problem. To come to grips with the affordability problem, a 15-year baseline procurement program should be established for each Military Department. Existing procurement programs should be re-evaluated in light of the baseline procurement program. Such an effort may lead to cancellation of some lower priority programs.

RECOMMENDATIONS

PRINCIPAL RECOMMENDATIONS

OSD should strengthen its guidance to the Military Departments for preparation of the Extended Planning Annexes (EPAs). Specifically, actions should be taken to ensure that each Department's EPA is prepared and presented consistently. More importantly, specific fiscal guidance for the total of each Department's procurement appropriations in each of the EPA years, as well as each of the POM years, should be included in the preparation instructions issued by OSD.

The DSARC should adopt a role in affordability determinations which is supportive of the PPBS, as discussed previously. In addition, we recommended that the DSARC ensure that any analytical methods presented at Milestone Reviews (e.g., unit cost vs. production rate) which could be used to generate information on the cost consequences of a change to the structure of a program (e.g., quantity reduction or stretch-out) are appropriate. Such information may be useful in PPBS deliberations.

OSD should develop an affordability analysis procedure for each Military Department to use in establishing its own 15-year baseline procurement program. This procedure should be used in conjunction with the PPBS deliberations and should provide a mechanism which:

- displays the three factors determining affordability (program priority, resource availability and program cost) and shows their relationships
- helps reconcile requirements and resources in the procurement accounts
- identifies the consequences of changes in the baseline procurement program
- permits early identification of potentially unaffordable or marginally affordable programs
- allows early identification of "planning wedges" (i.e., outyear resources reserved for specific programs) which can be used during DSARC deliberations as a constraint on program acquisition strategy

In addition, this procedure should display the various demands on procurement resources over a 15-year period.

AN AFFORDABILITY ANALYSIS PROCEDURE

A procedure for affordability analysis in the procurement funding area was developed during the course of this study. This procedure encompasses all the principles outlined above and is based on the use of an affordability matrix for the procurement appropriations. Each Military Department would develop its own matrix. Figure 1 is a hypothetical example of an affordability matrix.

Description of the Affordability Matrix. The matrix lists all programs in a Military Department (including non-DSARC programs) that will require procurement funding in any of the next 15 fiscal years. The programs are listed in order of priority. Priority is based on a military assessment of the need and essentiality for the program determined in a manner consistent with applicable JCS and NSC promulgations, national objectives, etc. In light of the recommendations herein that each Military Department should be given specific fiscal guidance for the procurement appropriations, it does not

FIGURE 1. HYPOTHETICAL EXAMPLE OF AFFORDABILITY MATRIX FOR A MILITARY DEPARTMENT

(In Millions of FY 1980 Dollars)

ESTIMATE OF REQUIRED PROCUREMENT FUNDS BY YEAR
(range of estimates shown for FY83 through FY95)

PROCUREMENT PROGRAMS, BY PRIORITY	FY81	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95
1	2,000	2,000	1,500 - 1,650	800 - 1,000											
2			500 - 600	600 - 750	1,000 - 1,200	700 - 900	500 - 600	400 - 475	400 - 475						
3	1,500	1,700	2,000 - 2,200	2,000 - 2,300	1,500 - 1,700	1,000 - 1,200									
4	500	600	600 - 650	500 - 600	900 - 1,100										
5						1,050 - 1,275	1,200 - 1,400	1,125 - 1,500	1,200 - 1,425	1,150 - 1,500	1,100 - 1,500	800 - 1,200			
6										750 - 1,100	1,000 - 1,400	1,500 - 2,000	1,500 - 2,100	1,000 - 1,400	800 - 1,100
7										200 - 300	500 - 700	1,000 - 1,300	1,200 - 1,600	1,000 - 1,400	750 - 900
8	1,100	750	600 - 700	500 - 600	1,600 - 1,850	1,400 - 1,700									
9	25	50	50 - 60	20 - 25	15 - 25										
10	800	600	400 - 450												
11											1,800 - 2,200	2,600 - 3,000	2,000 - 2,800	1,400 - 1,800	1,500 - 2,000
12						1,500 - 1,850	2,000 - 2,500	1,600 - 1,900	1,200 - 1,450						
13		400	450 - 500	450 - 520	500 - 600	500 - 650	400 - 475	350 - 400	250 - 300	250 - 300					
14	1,750	1,800	800 - 875	700 - 600	750 - 875	800 - 850									
15									1,000 - 1,200	1,250 - 1,550	1,500 - 1,900	1,750 - 2,250	1,500 - 2,100	1,200 - 1,500	800 - 1,000
16	150	200	200 - 220	150 - 175	200 - 250	150 - 175	100 - 130	100 - 135	75 - 100						
17								650 - 750	1,000 - 1,200	1,500 - 1,900	1,500 - 1,900	1,000 - 1,300	800 - 1,000	800 - 1,100	500 - 750
18	1,500	750	800 - 900	500 - 600											
19								750 - 850	900 - 1,100	900 - 1,150	1,000 - 1,350	1,200 - 1,500	900 - 1,100	900 - 1,150	750 - 900
20	1,800	1,800	1,900 - 2,000	2,100 - 2,400	1,800 - 2,100	1,100 - 1,300	1,000 - 1,250								
21							2,000 - 2,500	2,300 - 2,900	3,000 - 3,500	3,500 - 4,100	2,500 - 3,000	2,200 - 2,550	1,500 - 2,000	1,100 - 1,400	900 - 1,250
22	500	750	800 - 875	750 - 850	500 - 600										
23	1,000	1,200	1,200 - 1,300	1,500 - 1,750	1,400 - 1,650	1,350 - 1,800	1,100 - 1,350	500 - 700							
24											2,500 - 3,000	2,750 - 3,100	3,200 - 4,200	3,500 - 4,500	4,000 - 5,200
25	1,500	1,900	2,000 - 2,200	1,800 - 2,100	1,900 - 2,200	1,700 - 2,000	1,200 - 1,500	800 - 1,000							
26							850 - 1,000	1,100 - 1,400	1,500 - 1,750	2,000 - 2,500	1,500 - 1,900				
27	500	750	950 - 1,050	1,200 - 1,350	1,500 - 1,600	1,500 - 1,850	1,000 - 1,250								
28								1,500 - 1,800	2,000 - 2,400	2,500 - 3,000	1,800 - 2,300	1,500 - 2,100	1,200 - 1,700	1,000 - 1,300	1,100 - 1,400
29		800	1,000 - 1,100	1,200 - 1,350	1,900 - 2,200	1,200 - 1,400	800 - 950								
30												2,500 - 3,000	3,500 - 4,500	3,900 - 5,000	5,000 - 6,500
TOTAL	14,625	16,050	15,750 - 17,330	14,770 - 17,170	15,465 - 18,150	13,950 - 16,850	12,150 - 13,405	11,175 - 14,810	12,525 - 14,900	14,000 - 17,400	18,700 - 21,150	18,800 - 23,300	17,300 - 24,100	15,800 - 20,550	16,100 - 21,000
ESTIMATE OF AVAILABLE PROCUREMENT APPROPRIATIONS	9,160	9,363	9,550	9,741	9,936	10,135	10,338	10,544	10,755	10,970	11,190	11,414	11,642	11,875	12,112

appear necessary to consolidate the individual Department lists into one prioritized DoD list.

For each program the latest and best estimate of the procurement funds needed in each of the 15 fiscal years is indicated. These estimates should be consistent or capable of reconciliation with those used at the most recent DSARC review for the program to ensure that the most reliable information is being used in both the DSARC and PPBS processes. The quantity of each system to be procured in any given year (and hence the estimate of required procurement funds) should be based on the military assessment of the numbers required within a specific timeframe to counter the threat against which the system is to be deployed. These program estimates should be expressed in constant dollars, so as to eliminate the problem of forecasting outyear inflation rates. It is important that the estimates of procurement funds requirements be as accurate as possible. However, the difficulty in estimating outyear program costs is recognized. Therefore, in the hypothetical affordability matrix, the outyear estimates of required procurement funds for a given program are shown as a range.

Shown beneath the listing of programs in the affordability matrix is an estimate of available procurement funds for each of the 15 fiscal years indicated (1981 through 1995). For this illustration, outyear procurement appropriations were forecasted by applying a 2 percent per year real growth rate to assumed fiscal 1980 procurement appropriations of $9 billion. The Military Department forecasts of outyear resources should be consistent with OSD fiscal guidance.

Once the matrix is created, an affordability line can be estalished for each fiscal year. Affordability lines are shown as dashed lines in Figure 1. The sum of the estimated procurement funds needed for all programs above this affordability line should be less than or equal to the forecasted available procurement appropriations for that year. In the outyears there may be two affordability lines because there is a range of estimates for programs in those years. A program above the line is affordable because it and all programs with a higher priority can be accommodated within the forecasted available resources.

Use of the Affordability Matrix. The affordability matrices should be used in the PPBS process to establish a baseline long-range procurement program. They should be updated annually, at a minimum, and submitted with the Military Department POMs. The matrices would permit the Defense Resources Board (SefDef's principal advisory body in the PPBS process) to examine the probable outyear consequences of budget decision alternatives such as program stretch-out, deferral, or cancellation. They would also permit identification of the marginal programs which need a more thorough examination relative to affordability.

Affordability matrices could be used to allocate planning wedges to upcoming and existing procurement programs. This type of information could then be used by the DSARC as a constraint in determining how a program should be conducted. Allocation of planning wedges may also lead to stable funding for high priority programs.

Affordability matrices may also provide some insight into which areas should not be pursued in the Research, Development, Test and Evaluation appropriations. For example, a program which the matrix identifies as clearly unaffordable from a procurement standpoint should be thoroughly scrutinized prior to a decision to transition it from technology base effort (budget categories 6.1 and 6.2) into exploratory development (budget category 6.3).

The affordability matrix is flexible enough to permit easy demonstration of the impact of changes on the baseline long-range procurement program. For example, different matrices could be developed to show the effect on a Department's affordable procurement program of changes in:

- the forecast of outyear appropriation availability
- the relative priority of different programs
- the planned production quantities or procurement schedule or production rate for a particular program, using information and analysis from the DSARC process

In addition, the matrix would be able to show the impact of new requirements on the baseline procurement program. The matrix could be automated so that the effect of changes in one or more of the variables could be readily examined.

As previously indicated, the program information used in both the DSARC and PPBS processes should be consistent or capable of reconciliation. Therefore, the responsible for monitoring the affordability matrix should rest with the OUSDRE action officers who already monitor programs from both an acquisition management (DSARC) and resource allocation (PPBS) perspective. When the affordability matrices are submitted with the POMs, the OUSDRE action officers could verify for their individual programs the accuracy of the estimates of required procurement funds to ensure consistency with the figures used at the DSARC. They could also check the priority of their programs to ensure that there are no gross deviations from applicable JCS or NSC promulgations. Any discrepancies noted by the OUSDRE action officers could be raised as issues to be resolved by the DRB during its PPBS deliberations.

In summary, affordability is a resource allocation problem. Therefore, the PPBS process

should have the preeminent role in affordability determinations and the DSARC should have a supportive role. Finally, an affordability analysis procedure for procurement funding, using tools such as the affordability matrix, should be a significant contribution to solution of the affordability problem.

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THE LEADER/FOLLOWER CONCEPT IN ACQUISITION

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ABSTRACT

This is a report of a six month study of the experience of government and industry with "leader company procurement" for the purpose of providing a basis for decisions concerning when and how to use the method. The study consisted of a combination of an extensive literature search and interviews, including selected personnel from seven programs. The results of the study include identification of nine factors which affect the use of leader/follower and a decision model.

INTRODUCTION

The leader/follower concept in acquisition appears to be neither widely known nor commonly understood (at least, under that name), although the current DAR provisions (4-701, 4-702, and 4-703) have remained essentially unchanged since their first publication in May 1964. The concept, as described in 4-701, is as follows:

> Leader company procurement is an extraordinary procurement technique under which the developer or sole producer of an item or system (the leader company) furnishes manufacturing assistance and know-how or otherwise enables a follower company to become a source of supply for the item or system.

A search of the records of the ASPR Committee reveals that these provisions were one of the products of a "Reduction of Implementation Panel", under the Assistant Secretary of Defense, Installation and Logistics, whose purpose was to reduce the volume of regulations by combining similar provisions in the regulations of the three services into a single provision in the ASPR.

This anomaly--a relatively little known or understood name for an apparently well-known and understood concept--may serve to explain much of the uncertainty and ambiguity which has appeared during the course of this study, particularly in searching for and identifying those "special" characteristics which might serve to describe the leader/follower concept. Instead of a specific, well-defined concept applicable to meeting specific objectives under certain (applicable) conditions through use of specialized techniques, it appears that the concept (in practice) embodies a relatively wide set of objectives, conditions, and techniques intermixed with other related concepts (and practices). It may be argued that one of the unintended (or unexpected) consequences of this study is to de-mystify the term "leader/follower" and place it in its proper context among the many other concepts in the acquisition process.

THE STUDY

The overall strategy for the study can be described as an examination of current and recent experience, in terms of a search of the literature and interviews with knowledgeable individuals in procuring agencies and in industry, to identify what has been learned about the objectives to be achieved, the factors which facilitate or limit use, and methods and procedures.

The study was to be accomplished over a six months period in three equal stages. The first stage would consist, primarily, of identifying potential sources of information in the literature and in terms of knowledgeable individuals, and preparing for the gathering of data. The second stage would be devoted to the gathering of information through interviews with knowledgeable individuals. The third stage would develop, from the information received, guidelines and a decision-making model for applying the leader-follower concept.

KEY FACTORS

Objectives. In a nominal sense, ASPR (DAR) 4-701 provides a listing of objectives, one or more of which may be viewed as suggesting or justifying the use of leader/follower. With some rephrasing and interpretation it may be possible to consider this listing definitive, at least for the "objectives" which are considered initially by the procuring agency. Any discussion of objectives, however, is considerably more complex than this. From an analytical point of view, all of the several objectives can be subsumed as requiring the achievement of a more proximal or intermediate objective--establishing a second source. If there is any underlying objective in leader/follower, it is to establish a second source. Further, what makes leader/follower different, if at all, from other second sourcing methods is that it is a technique to achieve a more specific objective--facilitate the process through which a second source becomes able to effectively compete

and/or produce.

Characteristics of the Procurement. There are several characteristics of the procurement which, in conjunction with other factors, particularly objectives, facilitate or limit the use of leader/follower. However, it does not appear that any single characteristic, standing alone, would dictate use or non-use of leader/follower. For convenience in discussion, the characteristics will be presented in five categories. The first category includes those characteristics which are related to the size of the procurement. The second category includes the relationships of the procurement or program to other programs, both competitive and cooperative. The third category relates to technology, and, particularly, high technology. There appear to be at least two different technology-related characteristics: first, how "high" the technology is, and, second, to what degree the technology is "divisible." The fourth category relates to stability. Early establishment of program requirements and reasonable continuity during the phases, at least up until production is established, increases the ability to assess the applicability of leader/follower and, where indicated, to introduce it into the program plan. The fifth, and last, category relates to importance or visibility. This characteristic is, to some extent, a function of other characteristics, particularly program size; however, a relatively small program may have high visibility because it represents an exciting technology, is a critical component of other programs, or has attracted attention from some important decision-maker or stakeholder.

Reprocurement Data Base. If there is one single characteristic (given a decision to establish a second source) which determines the use (or non-use) of leader/follower, the reprocurement data base is the most likely candidate. If there is (or is expected to be) a reprocurement data base, or technical data package (TDP), sufficiently complete to allow a second source to effectively compete and/or produce, the "extraordinary" method of leader/follower is unnecessary. If, at the other extreme, the TDP is so difficult and complex to produce that even the assistance of the developer will not provide sufficient information for effective competition and/or production by a second source, leader/follower will be ineffective.

Characteristics of (Potential) Contractors. This characteristic apparently presents few initial problems in considering whether to use leader/follower, but is considered an important characteristic and, during the course of carrying out a leader/follower, these characteristics may become critical.

Characteristics of Procuring Agency. The term "procuring agency" in a generic sense may describe any one or more of several organizational elements. For our purposes we shall distinguish between the individuals (and/or organizational element(s)) directly concerned with initiation and carrying out of leader/follower and other decision makers or stakeholders. In this context, it appears that the characteristics of interest can be categorized as follows: administrative and technical resources; relations with other decision makers and stakeholders.

Relation Between Government and Contractors. A variety of direct and indirect contract relations may be used between the government and the contractors, including the forms specified in ASPR (DAR) 4-703. Similarly, a wide variety of contract provisions may be employed to assure that the requisite assistance is provided (and used). The choice of contract relationship and supporting provisions is, to a large degree, dependent upon the position of the parties: prior to establishing the relationship, at the time of establishing the relationship, and the expectations concerning future relationships.

Time and/or Timing. Time as a factor may affect the use of leader/follower in several ways, and interacts strongly with other factors, particularly: the characteristics of the item procured, characteristics of potential contractors, and the objectives to be obtained.

Rules and Regulations. The area of rules and regulations may be considered to include all of the imposed conditions (both limiting and facilitating) which are derived from the law. In general, this includes broad, generally applicable conditions as well as specific conditions, i.e., the ASPR (DAR) and derivative rules and regulations. Many, if not all, of the effects, both facilitating and limiting, of rules and regulations on leader/follower are similar to those experienced in comparable procurement situations, and, particularly, in second sourcing. It appears that there may be, in specific instances, some more significant effects because of specific provisions (or lack of provisions).

Process and Methods. Within the limits imposed by rules and regulations, and reflecting the nature of the program, the objectives to be achieved, and other characteristics or factors, the specific process used, and the choice made among alternative methods, is an important characteristic to be considered.

DECISION MODEL

Introduction. While a decision model could vary from the descriptive generalities of the present DAR provisions to an endlessly detailed branching algorithm, it appears that the most generally useful level of presentation would be in the form of a process description which identifies the factors associated with two decisions: a) whether or not to use (or consider using) leader/follower; and b) how to use it. The model is, basically, a sequential decision (flow) model, presenting the initial decision of "whether or not to use" in a series of steps keyed to critical factors, followed by the second decision of "how to use it" in outline form. The Overall Decision Model appears in graphical form in Figure 1.

The first of the two basic decision areas, "Whether to Use", consists of two stages: first, a brief look, or "preliminary analysis", to determine whether or not the feasibility and/or desirability of leader/follower is sufficient to warrant a more extensive and detailed analysis; second, a "detailed analysis". The "preliminary analysis" is, itself, in two parts: first, an examination of (primarily) three factors to determine if development or establishment of a second source is feasible and/or desirable; second, an examination which includes three additional factors to determine if use of leader/follower is feasible and/or desirable. If warranted by the previous stage, a more "detailed analysis" is then carried out, depending upon which of several objectives is the primary purpose to be achieved.

The second basic decision area is "How to Use" leader/follower. This, again, will draw upon the previous analyses, and deals with key questions, including timing, form of contractual arrangements, incentives to assure the transfer of manufacturing assistance and know-how, and other considerations.

Second Source Decision. The reason for considering the decision to second source first is that the issue of leader/follower doesn't arise unless there is the necessity for establishing a second source. In the early planning the decision on the number of sources to be developed may have been assumed or otherwise established; this may be a function of the nature of the procurement, e.g., small, one-shot buys, off-the-shelf commercial products, or of the assumptions and circumstances during the establishment of the program. Where the question has not been settled, the decision is likely to be sensitive to three interacting factors. The first factor is the presence of some objective which will be advanced (or which can only be achieved) by developing a second source; while there may be several objectives, the most likely ones are achievement of some advantage in the cost (of the production buy) and assurance of supply. These objectives are, in turn, sensitive to the second factor, the characteristics of the procurement, and, particularly, the size and the schedule. The third factor, time, enters in at least two ways: first, whether the time needed to develop a second source is available in the light of the previous two factors, and second, whether this decision is being considered early enough to allow introduction consistent with the time needed. There are other factors which may affect this decision, the most important of which is probably in the form of strong policy guidance.

Leader/Follower Decision. If, and only if, the previous decision were to develop a second source, preliminary consideration of leader/follower becomes necessary. For purposes of this decision, three additional factors are of particular significance. The first factor, commonality, tends to be assumed, but is essential; if items to be procured from multiple sources are only required to meet minimal functional requirements, i.e., "form, fit, and function", there may be little or no necessity (and it may be, in fact, undesirable) to insist upon a transfer of manufacturing information from one producer to another. The second factor, the reprocurement data base, is probably the most critical determinant of the feasibility and/or desirability of leader/follower. If the available (or expected) data base is "so complete" that potential second sources can be expected to produce and/or compete without "extraordinary" assistance from the original developer/producer, there is no need for leader/follower; if, in contrast, the data base is so inadequate (or the product is so novel and difficult to produce) that the original developer/producer will be stretched to put it into production himself, leader/follower will not only be impractical (or infeasible) but may also interfere with the original production run. Only in the "middle area" where the second source can (only) be put in a position to produce and/or compete through "extraordinary assistance" is leader/follower indicated. This introduces the third factor, characteristics of (potential) contractors, the (potential) willingness and ability of the leader and the follower. Other factors or considerations may include use of alternative techniques such as breakout or directed licensing.

Detailed Analysis. If the preliminary analysis indicates the likelihood that use of leader/follower for development of a second source is feasible and desirable, the next stage is to examine the question in more detail, and, for this purpose, it is convenient to conduct the analysis on the basis of the specific (primary) objective under consideration.

How to Use. An affirmative outcome of the above process presents a number of issues in planning and carrying out the use of leader/follower. Generally, timing and form of contractual arrangement are sensitive to the particular objective sought, while choice of incentives is, in addition, affected by the circumstances of the parties.

SUMMARY

This study [1] was directed to a brief review of the experience of government and industry with "leader company procurement" for the purpose of providing a basis for decisions concerning when and how to use the method. Leader/follower procurement, as defined in DAR 4-701, 2, 3 is an "extraordinary" method of second sourcing which requires the original developer/producer to provide assistance to a second source to enable him to produce and/or compete.

While leader/follower, and related forms, has been used at least since WWII, current usage appears to center on two related decisions. First, a decision to develop a second source, usually for one of two objectives: to achieve cost containment or cost savings through competing part or all of a large, extended production run; to achieve assurance of supply, either to meet a delivery schedule beyond the capacity of a single supplier, or to assure continued supply over an extended period. Achievement of the cost savings objective is usually realized where there is a large production run

over an extended period; assurance of supply usually arises as an objective out of the known or anticipated characteristics of the developer/producer. The second decision--to use leader/follower--appears where it is both feasible and necessary to provide extraordinary manufacturing assistance and know-how to the second source from the developer/producer.

For experienced acquisition and contracting managers, leader/follower introduces no new or unusual challenges, and the model and guidance in this report should provide a useful (and sufficient) framework.

Incorporation of specific authorization (in the DAR) to negotiate and/or develop second sources to meet explicit objectives (cost savings, assurance of supply, socio-economic) should be considered.

Policy guidance should be directed to early specification of priority objectives, to early establishment of program parameters needed for planning, and to assurance of operational discretion to meet changing conditions, including discretion to discontinue use of leader/follower.

ACKNOWLEDGEMENTS

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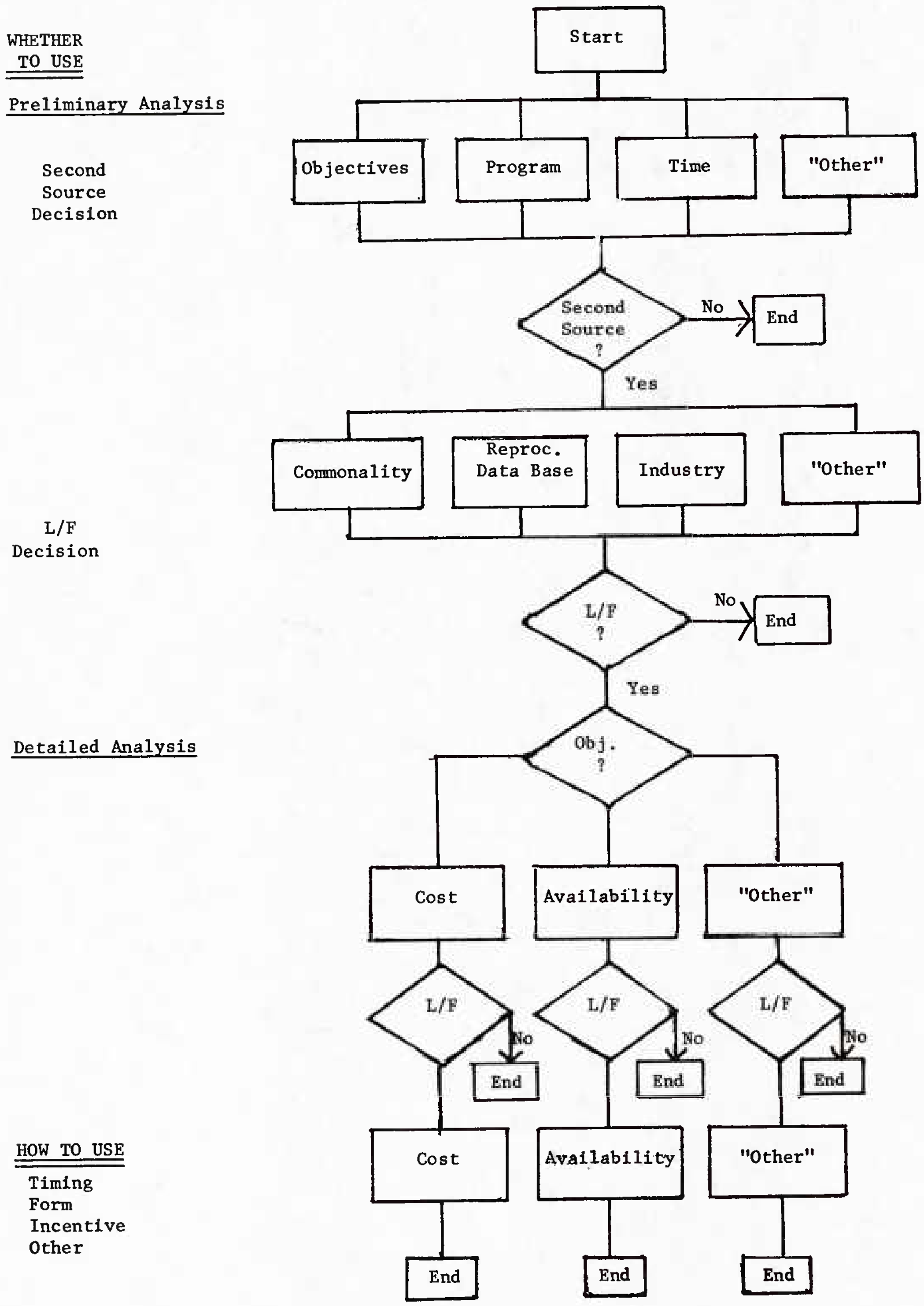
REFERENCES

[1] Thompson, C. W. N., and Rubenstein, A. H., "The Leader/Follower Concept in Acquisition," Final Technical Report, International Applied Science and Technology Associates, Inc. (IASTA), Evanston, Illinois, November 1979.

Figure 1

OVERALL DECISION MODEL



ADMINISTRATIVE INFORMATION

GENERAL INFORMATION

NINTH ANNUAL DOD/FAI ACQUISITION RESEARCH SYMPOSIUM

Registration Fees: All attendees (including Presenters and Panel members) are required to register and pay a registration fee. The Symposium registration fee is $60 per attendee and includes luncheons on Monday and Tuesday at the Officers' and Faculty Club, the Tuesday evening banquet at the Annapolis Hilton Inn, coffee service, a copy of the proceedings, symposium materials and support, and bus service at scheduled times between the meeting area and the lodging places at which blocks of rooms were reserved.

Badges: Badges will be issued to all attendees at registration time. Tickets for the 2 luncheons and the banquet are inserted in the badge holder behind the name card. These tickets will be required at meal times and should be protected against loss. Badges should be worn during all functions. Loss of badges or meal tickets should be reported to the administrative staff.

Symposium Office: The symposium administrative office will be located in the Lobby and Room 129 of Rickover Hall. This office will be in operation from 0730 on Monday, Tuesday and Wednesday until 1730 on Monday and Tuesday and until 1300 on Wednesday. On Sunday afternoon and evening and on Monday and Tuesday evening limited staffing will be maintained in Room 530 of the Annapolis Hilton Inn.

Meals: Luncheons on Monday and Tuesday will be held at the Officers' and Faculty Club within convenient walking distance of the session locations. Meal tickets are contained in the name badge holder. A set menu will be served buffet style.

The banquet on Tuesday evening, preceded by a no-host social hour commencing at 1830, will be held at the Annapolis Hilton Inn. Buses will operate between other lodging locations as listed on the program schedule. Additional banquet tickets are available at $17.50 each. Attendees will be asked to indicate a choice of entree between Roast Prime Rib of Beef and Maryland Crab Cakes at registration time.

Telephone/Bulletin Board: Incoming telephone calls for attendees may be made to the following numbers:

Commercial: (301) 267-2126 or 2620.
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A bulletin board will be maintained in the lobby of Rickover Hall to facilitate communication. The pay telephones located in the lobby of Rickover Hall will be used for all toll-charge outgoing calls.

Buses: Free bus service will be operated on a limited basis on the schedule listed on the Program between the meeting areas and the Holiday Inn/ Thr-rift Inn area and the Howard Johnson area. The Maryland Inn and the Annapolis Hilton are within walking distance but buses will be available in inclement weather. Buses will operate to and from the Annapolis Hilton on Tuesday evening as indicated on the Program. On Monday evening the buses

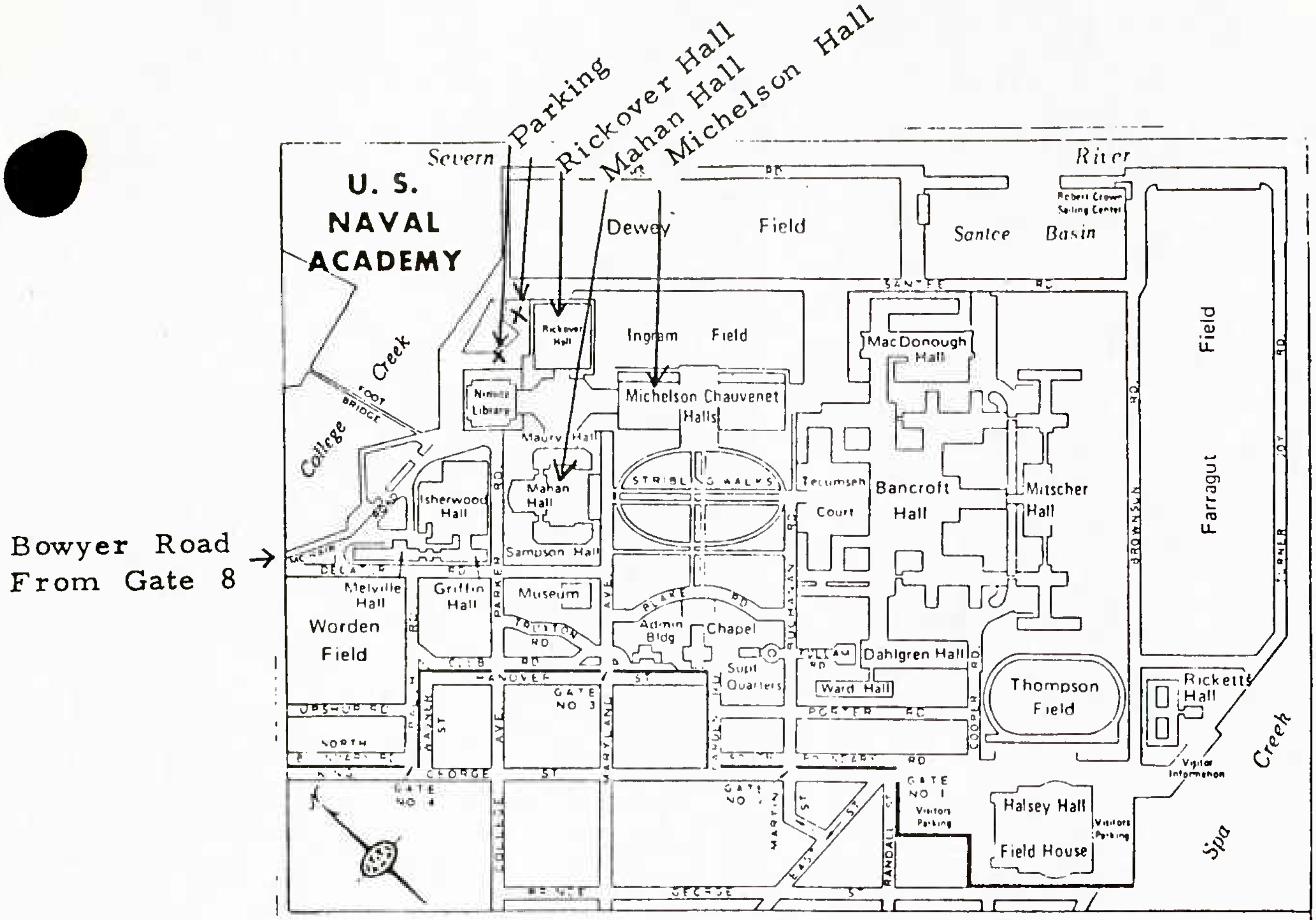
will be available at 1700 to take attendees to Hubbard Hall. This is the only change to the bus schedule from that listed on the Program.

Parking: Two designated parking areas are available adjacent to the meeting area. These areas and the routes to them are marked with symposium signs.

Social Hours: Informal social hours on a "pay-as-you-go" basis will be held at Hubbard Hall, Boat House on Monday evening, 9 June, from 1730 to 1830, and on Tuesday evening, 10 June, from 1830 to 1930, prior to the banquet at the Annapolis Hilton Inn.

Family Program and Recreational Facilities: Information has been mailed to attendees who indicated on the Registration Form that they would be accompanied by family members or guests. Similar information will be available at the Symposium Office following the peak registration period.

Automation Demonstrations: Computer Demonstrations, as announced in the Registration Instructions, will be held throughout the Symposium in Michelson Hall Rooms 101, 120, 121, 122 and 124. Specific schedules are posted outside each room.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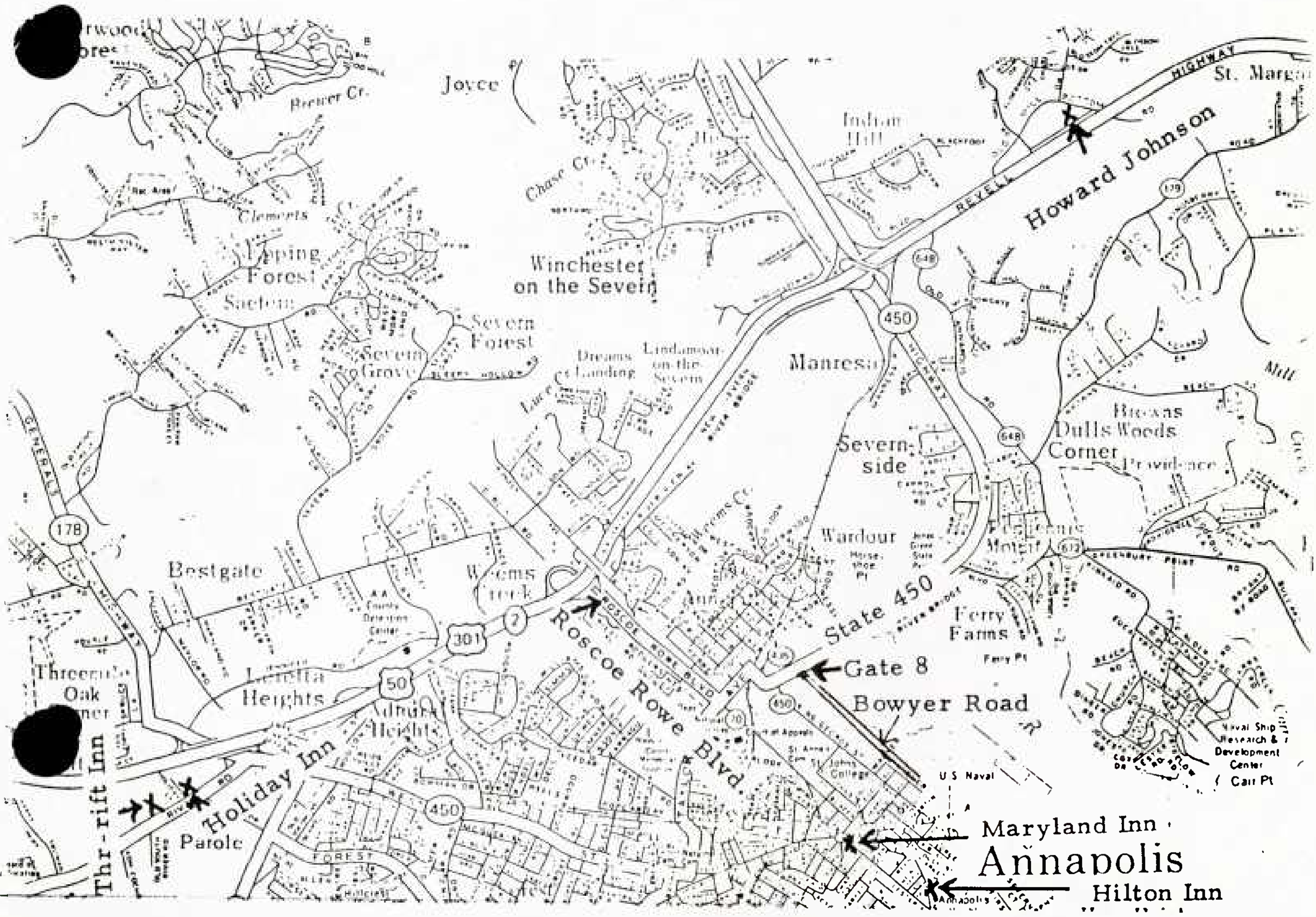
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